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BULLETIN of the American Association of Petroleum Geologists

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of the

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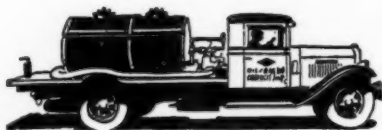
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BULLETIN
of the
**AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS**

MAY, 1937

SOUTHERN CALIFORNIA AS A
STRUCTURAL TYPE¹

R. D. REED²
Los Angeles, California

The structural and stratigraphic complexities of Coast Range geology have been dwelt upon by many writers. Whenever some bold spirit has proposed a classification designed to bring them into some sort of order, his contemporaries have generally remained unconvinced. Perhaps the best-known hypotheses of recent years have been based on the tacit assumption that no sort of regularity exists and hence that no real classification is possible. There is certainly something to be said for this view, as is sufficiently attested by the fact that a great deal has been said for it. If I have sometimes argued in the negative and have even once ventured to propose a new classification of phenomena, it was not without taking comfort from the fact that a skeptical attitude on the part of my hearers was inevitable. On the present occasion I am counting upon this same safeguard to prevent the harm that I might otherwise do.

The suggestion to which I particularly invite your skeptical attention is based on a recent attempt, by J. S. Hollister and myself, to work out some of the details of the geological history of the Cretaceous and Cenozoic basins and surrounding uplands in the Southern California province. As you may perhaps recall, we came to the conclusion that this province consists of subprovinces of a few distinct kinds, and that the subprovinces of each kind have been depressed, uplifted, folded, and faulted contemporaneously. The problem I wish to discuss to-day relates to the possibility of recognizing

¹ Presidential address read before the Association at Los Angeles, March 17, 1937. Manuscript received, March 9, 1937.

² Chief geologist, The Texas Company.

similar subprovinces, with similar successions of events, in other folded-Tertiary provinces of the world.

In the first place, I should like to call attention to a few maps and charts that may serve to bring to your minds the details of our conclusions. The Tertiary provinces³ of the Southern California district, including "granitic" areas, Franciscan "geosynclines," uplifts, embayments, and basins, are not physiographic, but rather tectonic. The several uplifts and embayments are named not because of the present topography but because of their history during the Tertiary. And the conclusion we have come to may be re-stated thus: Southern California is divisible into several provinces of a few types, and the different provinces of each type have had very similar post-Franciscan histories.

TABLE I
COMPARISON OF IMPORTANT EVENTS IN TWO AREAS OF UPLIFT IN
THE CALIFORNIA COAST RANGES

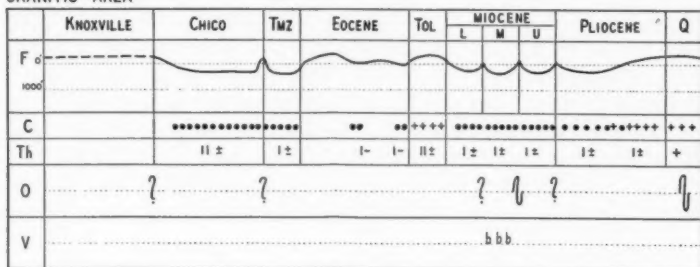
<i>Time</i>	<i>Diablo Uplift</i>	<i>San Rafael Uplift</i>
Pleistocene	Strong folding	Strong folding
Pliocene	Deposition at margins	Deposition at margins
End Miocene	Strong uplift	Strong uplift
Upper Miocene	Siliceous shale deposition	Siliceous shale deposition
Middle Miocene	Extensive transgression	Extensive transgression
End Lower Miocene	Vulcanism	Vulcanism
Lower Miocene	Beginning transgression	Beginning transgression
Oligocene	No record	No record
Upper Eocene	Coarse marine deposits	Fine marine deposits
Middle Eocene	Strong transgression	Strong transgression
Paleocene-Lower Eocene	No record	No record
End Mesozoic	Strong folding	Strong folding
Cretaceous	Thick sedimentation	Thick sedimentation
Upper Jurassic	"Nevadian" revolution	"Nevadian" revolution

To illustrate this conclusion it may be sufficient to show in tabular form (Table 1) the summarized histories of the Diablo and San Rafael uplifts. Both of them received sediments during the Franciscan, Lower Cretaceous, and Upper Cretaceous, and then were folded into broad anticlines with dips of 30 degrees or more. They were above the sea during Martinez and Lower Eocene time, were submerged during Middle and part of Upper Eocene, were largely emergent during Oligocene and Lower Miocene, generally submerged during Middle and Upper Miocene, and emergent except for special basins or troughs in the Pliocene, at or after the end of which came the strongest post-Mesozoic folding.

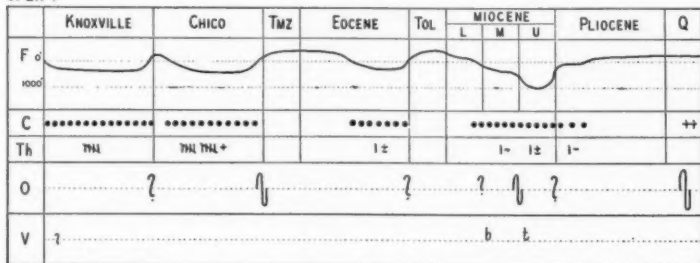
³ R. D. Reed and J. S. Hollister, "Structural Evolution of Southern California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 12 (December, 1936), Fig. 6, p. 1560.

In Figure 1 I have tried to show generalized histories for each of the three types of province, "granitic," uplift, and basin. It is ob-

"GRANITIC" AREA



UPLIFT



BASIN

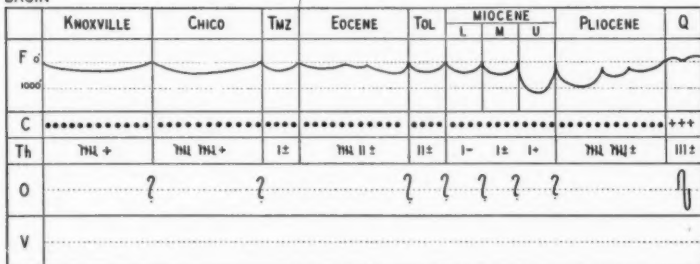


FIG. 1.—Structural history of three types of provinces in Coast Ranges. In column "C," dots indicate marine deposition, blank portions non-deposition, crosses continental deposition. For other symbols, see Reed and Hollister, "Structural Evolution of Southern California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 12 (December, 1936), p. 136.

vious that these three histories are different in a good many respects: or in other words that each type of graph has distinctive features.

After we came to this conclusion we wondered if tectonically com-

parable provinces with similar histories are to be found in the rest of the State, or perhaps in other parts of the continent, or in other continents. It seemed probable, of course, that other regions might have provinces of types not represented in Southern California: nappe regions, for example, or parts of ancient shields; but the more mobile provinces might nevertheless have uplifts and embayments similar in history to ours in some of their extra-nappe parts.

One serious difficulty had to be faced at the outset, and that was the difficulty of making accurate correlations between Southern California and any folded Tertiary region outside of the Pacific Coast of North America. It seemed possible, on the other hand, that enough

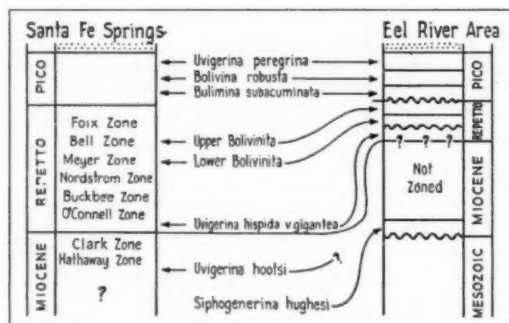


FIG. 2.—Comparison of stratigraphy in Los Angeles and Eel River basins.

tie-points might be found between California and some other districts so that we could judge whether or not the history graphs have similar shapes. The end of the Cretaceous is one such tie-point, and the end of the Pliocene just misses being another that can be recognized in many regions within a zone or two.

In order to proceed step by step rather than by a big jump, it will be well first to compare the Southern California basins with a basin in Northern California. I choose the Eel River basin, about 700 miles northwest of Los Angeles; an area in which several of my associates have made investigations during the last several years. It is a small basin, a few tens of miles in length and breadth, but contains several thousand feet of Miocene and Pliocene strata, most of them marine. Most of the details of the comparison I wish to make will be found in Figure 2. Some of the more important points may be itemized as follows.

1. The oldest fossils in this section occur in the beds lying on the Mesozoic basement rocks a mile or so north of Cape Mendocino. They are *Forminifera* belonging to the basal Middle Miocene zone that is the most strongly transgressive horizon in Central and Southern California.

2. The Pliocene strata contain almost exactly the same zones, in the same order, as the Pliocene of the Los Angeles Basin. The exceptions are particularly instructive: a. There is an omission of several subzones in the middle part of the Repetto, their position being marked by a striking disconformity. b. The Middle Pico contains not only the Middle Pico *Bolivina robusta* fauna of the Los Angeles Basin, but also, immediately below it, the *Uvigerina peregrina latalata* fauna of the Middle Pico of Ventura Basin.

3. Above the Upper Pico clays and silts, exactly like those of Southern California except that part of them indicate deposition in shallower water than the type Pico, comes a conformable sandy member, partly marine and partly nonmarine like the Saugus. The major folding of the Eel River Tertiary followed the deposition of this member. Afterwards there was renewed subsidence, deposition of Pleistocene sands, clays, and gravels, and renewed folding of a milder type.

If we assume, as many people believe, that the Pliocene foraminiferal faunas are merely ecologic assemblages, the remarkable parallelism of the Eel River and Los Angeles Basin faunas is still harder to account for except upon the assumption of closely similar depositional histories. In any case we must recognize here in Northern California the existence of a basin remarkably similar in Tertiary history to that of the basins of Southern California.

Turning now to the conditions in other continents, I must again select a single example, and will therefore choose one of the most interesting of all, the Malay Archipelago. One reason this area is interesting is because, in trying to learn something about it I became acquainted with a great body of geological literature the existence of which was previously all but unknown to me. Another interesting discovery was that some of the major contributions to this literature have been written in English, others in German or French. Some of the best papers, of course, are available only in Dutch, but a perusal of several of them has turned out to be more interesting and instructive, and considerably less difficult, than I anticipated.

In order to show a few of the more obvious parallels in the structural evolution of Southern California and the East Indies, I must point out briefly and sketchily a few of the more important features of the geography and geology of the East Indies. Figure 3 shows some

geographic items: the Sunda and Sahul shelves, the location of the low-lying jungle-covered areas as well as the mountains of Sumatra, Borneo, and Java, and the position of the volcanic belt. In order to furnish the perspective that most of us need when we think about conditions in the East Indies, I call your attention to the fact that the State of California is not quite so large as the single island of Sumatra, and not quite half so large as Borneo. Thus, when we undertake to compare the structure of Southern California with that of the East Indies as a whole, we must remember that Southern California is used merely as a sample of the Coast Ranges. It might be better to compare it with Sumatra, or with a part of Borneo, but to

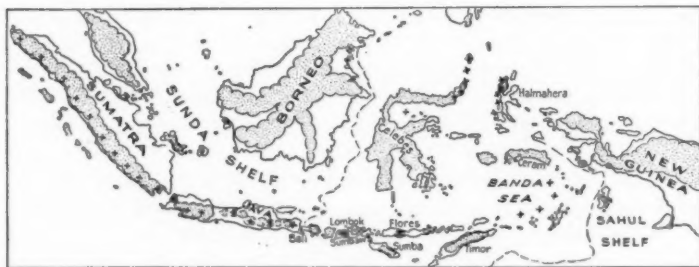


FIG. 3.—Some geographic features of the Malay Archipelago. The crosses indicate the position of belts of active volcanoes.

do so would conceal from view some regional considerations of great interest.

Figure 4 is a map designed to show geological data of several kinds pertaining to the East Indies. The data are taken from several published maps, but most largely from one by Professor Umbgrove, published in a chapter dealing with the relation between geology and gravity conditions of the region.⁴ This chapter is one of the most recent and best accounts of the geology of the Archipelago, and is written in English.

I wish to call your attention to four different types of province shown on this map. The belt marked "A-A-A" is Umbgrove's "polygeosyncline," which coincides with the remarkable zone of negative gravity anomalies discovered by Vening Meinesz. Topographically it is composed partly of islands and partly of a submarine ridge, and

⁴ Ph. H. Kuenen, J. H. F. Umbgrove, and F. A. Vening Meinesz, "Gravity, Geology and Morphology of the East Indian Archipelago," extract from *Gravity Expeditions at Sea* (1923-1932), Vol. II, "The Interpretation of Results." Publication of the Netherlands Geodetic Commission (1934).

is bordered in part of its course by deeps. As Umbgrove explains, the history of each of these islands, so far as now known, is practically identical with the history of all the others. There is a post-Mesozoic folding, an Eocene transgression, a pre-Middle Miocene folding period (possibly more than one), a strong Middle Miocene transgression, an intensive post-Middle Miocene folding phase, local Pliocene trough formation, and post-Pliocene folding. It is interesting to notice, furthermore, that a great many earthquake epicenters lie along this belt.

"B-B-B" is a "geanticlinal" belt, of which the history differs in many respects from that of belt "A-A-A." Instead of listing the events separately I shall show them in graphic form a little later.



FIG. 4.—Some geological features of the Malay Archipelago. See text for explanation.

Perhaps the most interesting of all the provinces is the "idio-geosyncline" of Umbgrove, different examples of which are labeled "C." These are of particular importance as the sites of all the Tertiary oil fields of the East Indies. They are in general large, oval-shaped areas of jungle-covered lowland more or less interrupted by low hills. They are underlain by an immensely thick Tertiary section, the older part of which is commonly not observable except about the margins. All of the Tertiary formations are supposed to be essentially conformable in the centers of the basins, and all were folded at a time identified by the Dutch geologists as the end of the Pliocene. The beds called Pleistocene lie unconformably on the folded Pliocene and are themselves folded and faulted only to a comparatively minor degree. It is in some of these less folded beds in east-central Java that Dr. DuBois found *Pithecanthropus erectus* about 45 years ago. The question of their age has been exhaustively discussed in an English book written by a Dutch geologist a few years ago.⁵ This

⁵ L. J. C. Van Es, *The Age of Pithecanthropus*, Martinus Nijhoff (The Hague, 1931).

book, by the way, is remarkable for showing a great deal more about the details of structure of the Pliocene beds of Java than do any writings about oil geology that I have seen.

If you go to the East Indies to carry out explorations for oil, it is likely that you will see a great deal of these idiogeosynclines, and that you may find them depressing and uninteresting. From this distance, however, they seem to have many fascinating features. As you will notice, many of them lie on the opposite side of the geanticline from the polygeosynclinal belt, and abut against the area already mentioned as the Sunda shelf. As a matter of fact, as Molengraaff long ago pointed out,⁶ the oil basins of Sumatra, Java, and eastern Borneo are all marginal to the Sunda shelf.

This shelf is another tectonic province, a stable region with a "granitic" core. It is a continuation of the Malay Peninsula, with its granite and other pre-Cretaceous rocks, including its tin ores. Much of the world's tin actually comes from two islands near Sumatra on the Sunda shelf, Banka and Billiton. Smaller islands are found here and there, like Bawean Island north of Java, to support the suggestion that the entire Sunda shelf is a pre-Cretaceous "granitic" area that took a relatively inactive part in the tempestuous post-Jurassic history of the better known parts of the Archipelago. As a matter of fact the Dutch geologists assume that the entire shelf, which they call "Sundaland," was a land area practically throughout the Tertiary and Pleistocene and that it was submerged beneath the sea by the rise in sea-level accompanying the melting of the glaciers in countries lying farther poleward. Old river courses can still be traced across Sundaland from the mouths of streams on Sumatra, Java, and Borneo. This and other evidence seems to demonstrate a fairly recent submergence, whether or not the melting of the glaciers be accepted as its cause.

In many of the tectonic maps of the East Indies and in some of the paleogeographic maps—for example, Badings' maps of the Paleogene⁷—a part of southwest Borneo is indicated as a peninsula of Sundaland. A comparison with Salinia or Anacapia of California is suggested, but the data are too few to permit a conclusion to be reached. In any event, Sundaland bears some resemblance to Mo-havia, and the idiogeosynclines suggest a comparison with some of the

⁶ G. A. F. Molengraaff, "On the Geological Position of the Oilfields of the Dutch East Indies," *Proc. Kon. Acad. van Wetenschappen Amsterdam*, Vol. 23 (1920), pp. 440-47.

⁷ H. H. Badings, "Het Paleogeen in den Indischen Archipel," *Verhandelingen van het Geologisch-Mijnbouwkundig Genootschap voor Nederland en Kolonien*, Geol. ser., Deel 11 (1936), pp. 233-99, Pls. 1-4.

Tertiary embayments or basins of the Coast Ranges. Whether or not the "geanticlinal" belt is much like one of our "uplifts" is more difficult to say. The "polygeosynclinal" region, finally, when compared to any of the provinces of California, seems to show more differences than resemblances. We seem to have no Tertiary geosynclinal belts that challenge comparison with it in length and character.

In order to bring out the differences and resemblances as far as possible, I present Figure 5. The graphs for East Indian areas are se-

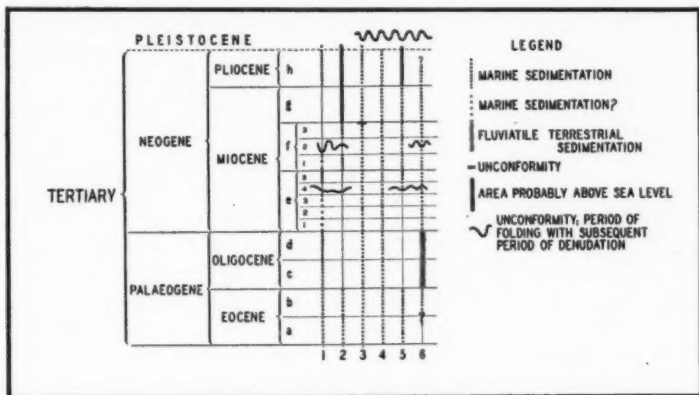


FIG. 5.—Comparison of Tertiary history of three East Indian and three Californian subprovinces. Column 1 is for the Tanimber Islands in the polygeosynclinal belt; column 2 for the Djiwo area, eastern South Java, in the geanticlinal belt; column 3 for Mangkalihat Peninsula, East Borneo, an idiogeosynclinal area; column 4 for Ventura Basin; column 5 for part of the San Rafael uplift; column 6 for the San Joaquin Hills, southeast margin of Los Angeles Basin.

lected from a large and comprehensive chart by Umbgrove, published in the paper already quoted. The remaining graphs are prepared according to Professor Umbgrove's method. They show the history of Ventura Basin, of an area in the San Rafael uplift, and of the San Joaquin Hills near Los Angeles Basin.

A full discussion of these graphs would be too long to present here, but some of the more striking features may be worth considering. One of the most interesting episodes of the East Indies is the Miocene transgression, often called the Bebulu transgression and dated as Tertiary e_6 . It followed a poorly dated folding episode, and was sufficiently extensive to permit the sea to cover many districts that can not be proved to have been submerged during the Lower Tertiary. Not long after the deposition of Tertiary e_6 , in a period

called Tertiary f_2 , came a folding episode that was locally the strongest of all post-Mesozoic orogenic phases. After the deposition of additional material considered to be Upper Miocene, came the formation of the Pliocene troughs in the polygeosynclinal region, and also a great part of the subsidence of the idiogeosynclines.

The exact correlation of even Tertiary e_3 is uncertain, but the consensus of geological opinion seems to be that it can not be far from Burdigalian. In California terms, that may be about the time of the "button bed," or the beginning of Middle Miocene, also a transgressive period of note. If we make this correlation, it is natural to assume that the Tertiary f_2 orogeny must have come at a time not far from that of the pre-Modelo folding of the Coast Ranges.

The Miocene-Pliocene boundary seems to be a bit vague in the Indies, just as it is in California. In both areas Pliocene sedimentation seems to have taken place largely in comparatively small troughs and basins. The end of the Pliocene in the Indies is generally taken as the period of strong folding of the basins. In California, on the other hand, the end of the Pliocene is generally considered to have antedated the strong folding movements. Whether or not there is good paleontological evidence for either boundary is perhaps doubtful. If the subject were to be carefully studied by an impartial committee of paleontologists it seems entirely possible that their decision would be that the folding period itself offers as good a tie-point as the fossils.

Pre-Neogene Tertiary stratigraphy is not sufficiently well known in the East Indies to make possible a profitable comparison as to details. The beginning of the Tertiary—that is, the post-Cretaceous folding period—may be taken as probably contemporaneous on the two sides of the Pacific Ocean. Dutch paleontologists generally mention two stages, Tertiary a and b , for the whole Paleocene-Eocene sequence. This classification is obviously not fine enough to permit any discussion of possible parallels. The Oligocene, on the other hand, classified as Tertiary c and d , is more closely subdivided than the California Oligocene, and again it is not easy to discover parallels or to prove their absence.

Pre-Tertiary stratigraphy is also poorly known in the East Indies, but there are nevertheless several interesting parallels between that province and the Coast Ranges. The basement in many areas is described in terms that would serve well for the Franciscan, for example, and that of other areas is as clearly "granitic" in the California sense. There seems to be a well-marked Cenomanian transgression, but the Upper Cretaceous is much more largely limestone than that

of California. The post-Cretaceous folding episode, which is recognized nearly everywhere in the Archipelago, has already been mentioned as a striking parallel.

On the whole, this attempt to correlate the structural evolution of California and the East Indies looks less fantastic the more we consider it. Many striking analogies are evident at once, and no profound disagreements have yet been found.

When we come to the subject of drawing conclusions there is not much that is specific to say. If the suggested analogies between geological events of California and the East Indies can be demonstrated, the number of important conclusions to be drawn will be large. For the present, however, about all I can say is that the pursuit of the subject is interesting and informative. It leads one to take an active interest in subjects of which he had been previously content to remain ignorant. So long as ultimate success is not impossible, moreover, the subject is capable of making a strong appeal to a sufficiently active imagination. If California and the East Indies have had parallel post-Jurassic histories, it would seem that the whole circum-Pacific mobile belt may be expected to share in these parallels. And if the circum-Pacific belt, why not the West Indies and northern South America, which many geologists consider as part of the circum-Pacific belt anyhow? And if the West Indies are included, why not all Tertiary mobile belts everywhere?

If this outcome of the investigation is admitted to be even a possibility, it follows that those of us who work in Southern California, or in Venezuela, or in New Guinea are not, as we may sometimes suppose, engaged merely in dull provincial work, of routine character; instead we are working out the scheme of structural evolution of all the areas on earth that enjoyed any exciting history during post-Paleozoic time. It follows also that the best possible place to learn about the history of mobile belts in general is the place that has the best and most accessible outcrops, and the pleasantest working conditions. Far be it from me to say that Southern California is that place, and yet, unless you expect to visit a better one soon, perhaps you will enjoy considering it while you are here, as a possible candidate for the honor.

SOUTH BURBANK POOL, OSAGE COUNTY,
OKLAHOMA¹

E. O. MARKHAM AND L. C. LAMAR²

Tulsa, Oklahoma

ABSTRACT

Accumulation of petroleum in the South Burbank pool, located in Ts. 25 and 26 N., R. 6 E., was produced by the lensing out of the Burbank sand toward the east into Cherokee shale. Production is limited on the west by water, lack of sand, lack of porosity, or any combination of the three.

The major features are two long ridges which were developed during deposition, paralleling the sand body which trends north-south. Compaction folds, conforming in a marked degree to the top of the sand, seem to have been formed in the "Oswego lime" by compaction of the Cherokee shale over and around the sand body. These compaction folds are not reflected on the surface. Later folding has caused the formation of structures at nearly right angles to the ridges. These structures are found on the surface, and they also influence the compaction folds. In spite of rather erratic sand conditions, there seems to be a definite relation between the structure of the sand, the sand thickness, and the initial production. A gas cap is found on the higher parts of the east ridge.

HISTORY

On January 5, 1934, the Mead Oil Company, Al Beck, Bridgeport Machine Company, *et al.*, completed a well in the NE., NE., SW. of Sec. 10, T. 25 N., R. 6 E., for 1,647 barrels of oil at a total depth of 2,857 feet in the Burbank sand. This well proved the contention held by many that a link would be found connecting the old Burbank pool and the Fairfax pool. Other companies had made a play in this direction, but with little success.

The Sinclair Oil Company drilled a well $\frac{1}{2}$ mile north of the Fairfax pool, which had an initial production of 100 barrels, and The Carter Oil Company drilled several wells in Secs. 34 and 35, T. 26 N., R. 6 E. Both of these plays later proved to be on the edge of the South Burbank pool.

In spite of adverse economic conditions, intense interest was manifest in the area by both large and small operators. The highest price paid for a single lease of 160 acres was \$342,000.00 and the lowest was \$50.00.

The pool, as a whole, has been carefully developed. During its early history, a few operators depended on drillers for records of the wells with the result that information which could be obtained only

¹ Presented before the Association at Los Angeles, March 17-19, 1937. Manuscript received, March 1, 1937.

² Geologists, The Carter Oil Company.

by samples was lost, but since the first flurry of activity, accurate records and samples have been kept, making a detailed study possible.

A total of 259 wells had been drilled January 5, 1936, in the pool proper, of which 245 were oil wells and 14 were dry holes. This is a very low percentage of dry holes for this type of pool, and is due to careful development. The pool covers an area approximately $5\frac{1}{2}$ miles long and $1\frac{1}{4}$ miles wide, and has proved an area of approximately 4,140 acres. This makes an average spacing of 16 acres per well.

Initial production of the wells has ranged in size from 10 or 15 barrels to 5,786 barrels per day.

GENERAL GEOLOGY

The structure of the South Burbank area is a monocline dipping gently toward the south and west at a rate of about 40 feet per mile, interrupted by small folds. It is in the southwest part of an area devoid of Chattanooga shale, which covers the north-central part of the Osage area and the adjacent area in Kansas.³

The surface rocks belong to the Elmdale and Sand Creek formations⁴ of Pennsylvanian age. The surface structure has been mapped by the United States Geological Survey and published by the Department of the Interior.⁵

Production is coming from a sand lens of the off-shore bar type⁶ which is found within the Cherokee shale. Accumulation is controlled by the sand body pinching out into shale on the east, thus forming a trap for the oil. Some oil is being produced from the "Mississippi lime," but it is negligible in quantity.

The only unconformities of any magnitude are found at the top and base of the "Mississippi lime." Little is known in the South Burbank area about pre-Pennsylvanian folding, or the amount of erosion,

³ F. L. Aurin, G. C. Clark, and E. A. Trager, "Notes on the Subsurface Pre-Pennsylvanian Stratigraphy of the North Mid-Continent Fields," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5, No. 2 (March-April, 1921), p. 136.

G. S. Buchanan, "The Distribution and Correlation of the Mississippian of Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11, No. 12 (December, 1927), pp. 1307-20.

N. W. Bass and Constance Leatherock, "Chattanooga Shale in Osage County, Oklahoma, and Adjacent Areas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 1 (January, 1936), pp. 91-101.

⁴ H. D. Miser (compiled by), "Geologic Map of Oklahoma," *U. S. Geol. Survey* (1926).

⁵ C. F. Bowen, in David White and others, "Structure and Oil and Gas Resources of the Osage Reservation, Oklahoma," *U. S. Geol. Survey Bull.* 686-L (1922), pp. 145-47.

⁶ N. W. Bass, Constance Leatherock, W. R. Dillard, and L. E. Kennedy, "Origin and Distribution of Bartlesville and Burbank Shoestring Oil Sands in Parts of Oklahoma and Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 1 (January, 1937), pp. 30-36.

since few wells have been drilled to the Simpson formation and only edge wells have been drilled to the top of the "Mississippi lime."

Minor folds, which are not reflected on the surface, occur in the "Oswego lime." The surface folding, however, is reflected on the "Oswego lime," and its axis is at nearly right angles to the folding mapped on the "Oswego lime" paralleling the Burbank sand ridges. This relationship will be discussed in detail under "Structure of Oswego Lime."

Stratigraphy of the area is not discussed in detail in this paper since it has been thoroughly covered by previous papers⁷ and is essentially the same as the North Burbank pool.

TABLE I
SUBSURFACE SECTION SHOWING KEY BEDS ONLY AT SOUTH BURBANK
PENNSYLVANIAN -

	Red Eagle limestone
	Foraker limestone
	Grayhorse limestone
	Stonebreaker limestone
	Bird Creek limestone
	Elgin sandstone
	Layton sandstone (oil showings)
	Cleveland sandstone (oil showings)
	"Big lime"
	Peru sandstone (oil showings) lenticular
	"Oswego lime" (oil showings)
In	(Prue sandstone (oil showings) lenticular
Cherokee	"Pink lime"
formation	Burbank sandstone (main producing horizon)
MISSISSIPPIAN	"Mississippi lime" (some production)
ORDOVICIAN	Tyner formation
ORDOVICIAN AND CAMBRIAN	Arbuckle limestone

The part of the section of particular interest to this paper is shown in greater detail in Figure 1 to give a better idea of the comparative thickness and relation of the various formations to each other.

STRUCTURE

PRE-PENNSYLVANIAN

Although only a few wells have been drilled to the Tyner formation and none to the Arbuckle limestone in the close vicinity of South Burbank, there was undoubtedly a great deal of erosion after the

⁷ C. F. Bowen, in David White and others, *op. cit.*, pp. 137-42, Pl. 21.

¹ H. T. Beckwith, "Oil and Gas in Oklahoma; Geology of Osage County," *Oklahoma Geol. Survey Bull.* 40-T (February, 1928).

N. W. Bass, L. E. Kennedy, W. R. Dillard, and Constance Leatherock, "Subsurface Geology of Osage County, Oklahoma," *U. S. Dept. Interior Press Rept.* 105368 (January, 1936), pp. 4-49, Pl. 1.

deposition of the Tyner and before the deposition of the "Mississippi lime" as evidenced by the absence of the Chattanooga shale.

After the deposition of the "Mississippi lime," another period of erosion peneplained the area and leveled the structures formed dur-

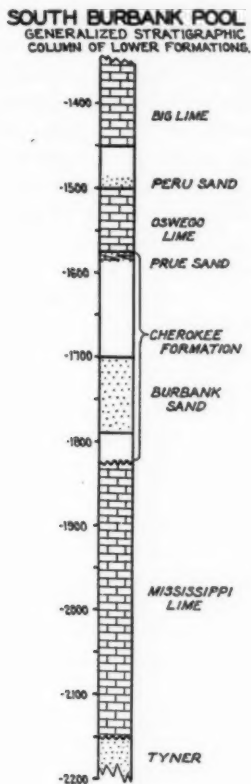


FIG. 1

ing the Mississippian period. There is not enough information to detail these structures, but they must have been of some magnitude, for the "Mississippi lime" varies in thickness from 298 to 428 feet in the South Burbank area.

Regional contours on top of the "Mississippi lime" indicate a flattening from east to west across the pool. Just what relation this pre-Pennsylvanian structure, or topography, has to the accumulation

of the Burbank sand is not known, although it may have acted as a check on currents, causing the bars to begin forming at that locality.

Eighteen wells have been drilled to the "Mississippi lime" and production has ranged from 5 to 75 barrels of oil per day.

PENNSYLVANIAN

BURBANK SAND

During Cherokee time the entire area was again submerged and the deposition of the Cherokee formation began. In the lower part of this formation are found the Bartlesville sand in eastern Osage County and elsewhere in northeastern Oklahoma, and Burbank sand in western Osage County and adjacent areas in southern Kansas. These two sands are the principal oil-producing beds of northeastern Oklahoma.

As the Cherokee sea advanced and receded upon the land, sand bars were formed along the shores, one of which is the productive sand body in the South Burbank pool.³

The productive part of this sand, to which the "pay" in this paper is referred, varies from a few inches to about 100 feet. The Carter Oil Company's Oliphant No. 4, Sec. 10, T. 25 N., R. 6 E., drilled 99 feet of pay sand and had not as yet reached the base. Near-by wells, however, had only 90-95 feet of "pay" and so it is estimated that 100 feet is about the maximum thickness.

The average thickness is estimated to be about 65 feet, although data in the southwest part of the pool are lacking.

It is not always true that the total amount of "pay" drilled is productive. Several wells have been drilled in which shale partings were found, and in some places porosity varies from 6 to 25 per cent in the same well. This may be due to either irregular cementation or shale inclusions.

The best production may be found in any part of the "pay," but the largest wells in the pool have produced from the upper few feet of sand—notably the Sinclair-Prairie No. 6, Tract 140, in the SE. $\frac{1}{4}$ of Sec. 9, T. 25 N., R. 6 E., which had an initial production of 5,786 barrels and was the largest well in the field, and the Midco Oil Corporation's Adlum No. 5, NW. $\frac{1}{4}$ of Sec. 10, T. 25 N., R. 6 E., which had an initial production of 5,300 barrels.

It is noteworthy that neither of these wells had any appreciable amount of sandy shale above the "pay."

A few porosity tests of the sand have been made, but not enough

³ N. W. Bass, Constance Leatherock, W. R. Dillard, and L. E. Kennedy, *op. cit.*, p. 55.

to give an accurate estimate of the average porosity of the sand in the pool. In five such tests, porosity varied from 14 per cent to 25.8 per cent. It is estimated from these tests and from the cuttings that a fair average would be about 17 per cent for the productive part of the sand.

Growth ridges⁹ which were well developed during deposition of the sand body have been fairly well preserved; and in spite of widely varying sand conditions, the areas of high initial production follow these ridges (Fig. 2). Since these ridges are not only structurally higher than adjacent areas, but are also areas of thicker pay sand, it is questionable which is the more important feature. It is the writers' opinion that thickness is probably the more important. A similar condition exists in the Burbank pool, though not so pronounced because the ridges have not been so well preserved.

Above, and lying directly on the pay sand is a sandy shale which seems to be a distinct and later phase of deposition rather than a gradation from sand to shale. Available cores and samples show that the change from a very tight, silty, impure sand to a good porous sand generally occurs within less than five feet.

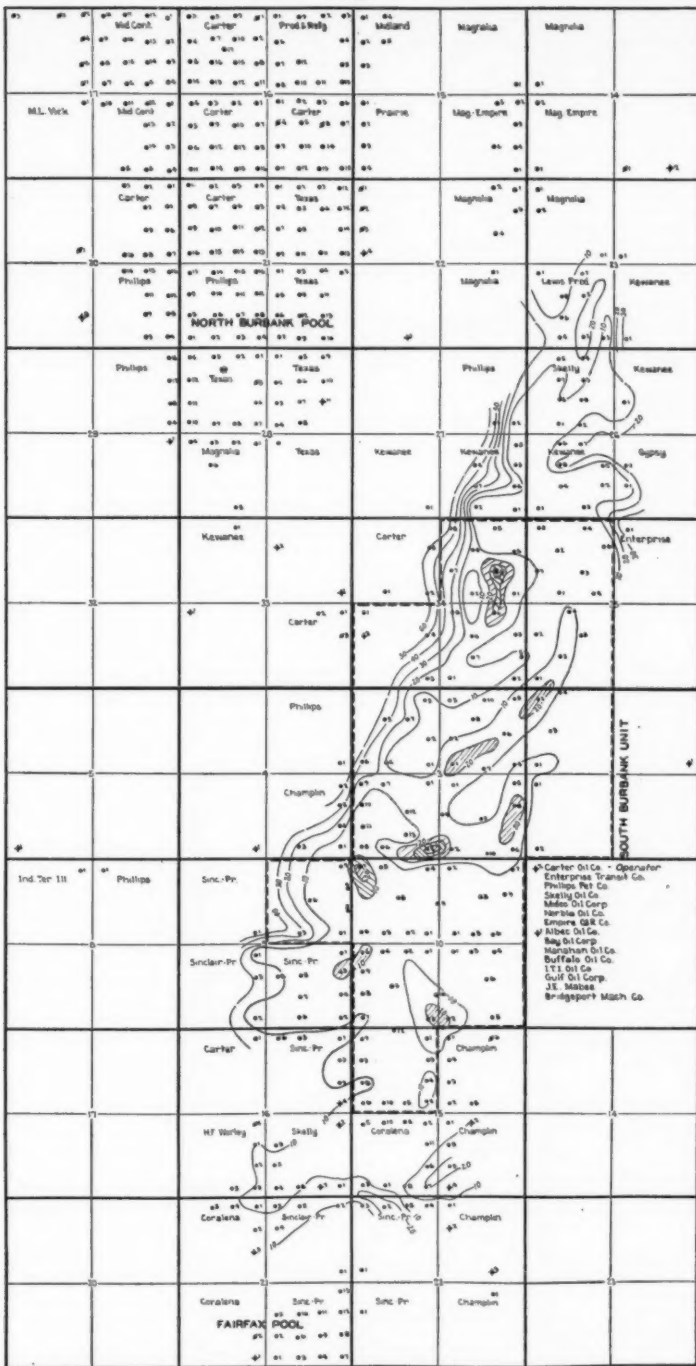
It appears probable that after the formation of the South Burbank sand bar, submergence carried it below the zone of effective wave action, and the lower areas on top of the bar were partly filled with sandy shale. The areas in which the pay sand is found structurally low are areas of thick sandy shale (Fig. 3). Continued submergence, then, carried the shore farther from the bar, and the sandy shale grades into the shale above. Generally speaking, the low structural areas and the west side and south end show the greater sandy shale thickness, with the east side and the high structural areas having only a few feet. A maximum thickness of 72 feet is found in the Carter's Cook No. 3, NE. of Sec. 9, T. 25 N., R. 6 E.

An isopach map on both the Burbank "pay" and sandy shale above (Fig. 4) shows the growth ridges with the steep dip where the sand pinches out toward the east and with a more gradual thinning on the west side. This is due to both sandy shale and sand pinching out on the east side, while the sandy shale compensates for the loss of pay sand on the west side. The bar shape is more pronounced on the pay thickness (Fig. 5) because of the "filling in" and compensation of the sandy shale.

Water is encountered along the west side and south end in most of the wells which have been drilled 1,765 feet below sea-level or

⁹ N. W. Bass, Constance Leatherock, W. R. Dillard, and L. E. Kennedy, *op. cit.*, pp. 44-45.

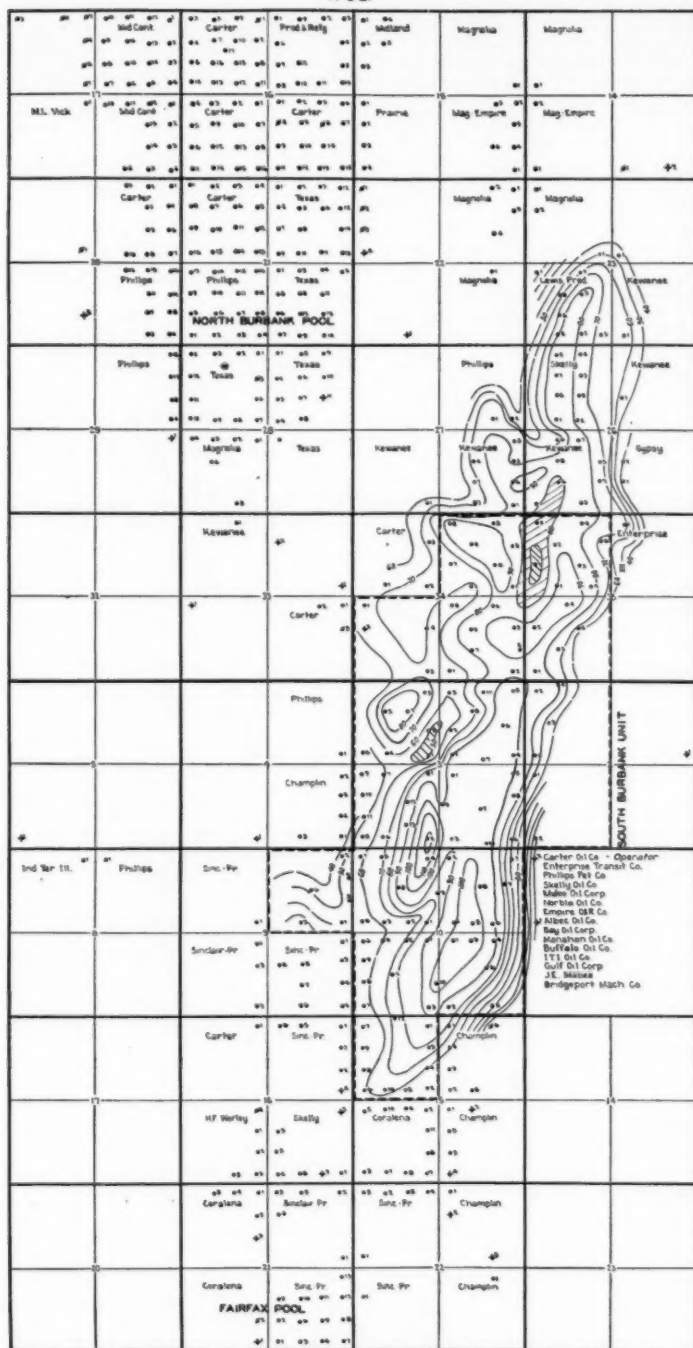
R. 6 E.



SOUTH BURBANK POOL
ISOPACH MAP ON BURBANK SANDY SHALE
Isopach Lines = 10 Ft.

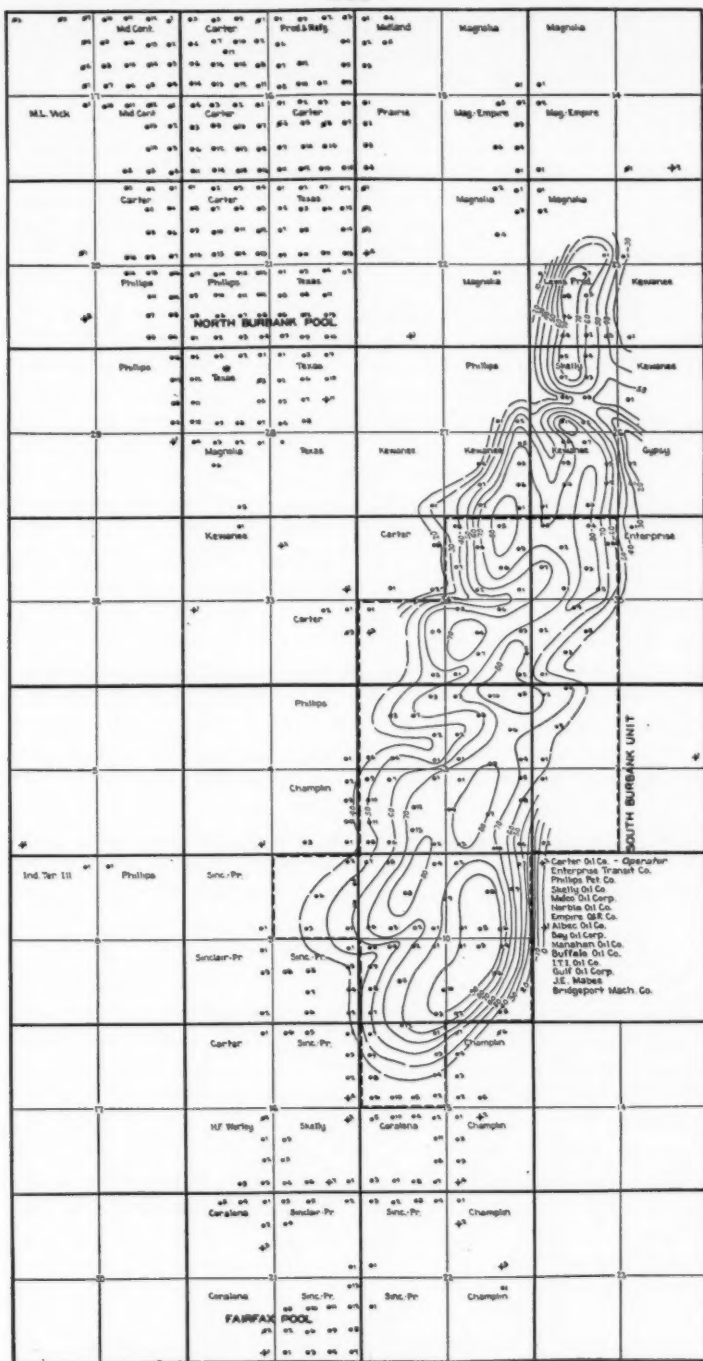
FIG. 3

R 6 E.



SOUTH BURBANK POOL
ISOPACH MAP ON BURBANK SAND.
(Both 'Play' And Sandy Shale Above)
Isopach Lines - 10 Ft

R 6 E.



T 25 N.

T 25 N.

SOUTH BURBANK POOL
 CONTOURED ON THE THICKNESS OF THE BURBANK PAY.
 Contour Interval: 10 Ft.

FIG. 5

deeper. The variation in the water level is probably due to both lateral and vertical changes in porosity. Small semi-isolated traps with slightly different water levels may be formed by lateral variation of porosity; the part of the hole below the average water level may be in "tight" sand; or, in the case of dry holes, the part of the sand down to where water was encountered may lack porosity.

A peculiar condition exists in this connection which has not been satisfactorily explained. On the north end and east side of the pool, wells have been drilled to 1,800 feet below sea-level without encountering water. Although the lowest part of the sand is not considered to afford prolific production, yet the porosity is enough to allow water to enter. A gummy condition of the lower part of the sand has been noted in wells in which the samples were complete, and it may be possible that this condition was present before the water level was established and has acted as a barrier to its later intrusion.

A gas cap is found on the higher parts of the east ridge, but most of the gas in the pool is found in solution. The largest amount of gas found in any of the wells was estimated at 15 million cubic feet per day and was found in the Midco's Adlum No. 5, NE., NW., NW. of Sec. 10, T. 25 N., R. 6 E. It was at first thought that the separation of oil or gas was due to shale partings or variation in porosity, but examination of cores in several wells in the gas cap area showed that the free gas and oil were coming from sand of approximately the same porosity and with no difference in lithologic character.

Bottom-hole pressure surveys made during the early development of the pool show a high-pressure area along the east side of Sec. 3, T. 25 N., R. 6 E., which swings toward the west in Section 10 and overlies remarkably well the structure on the east ridge.

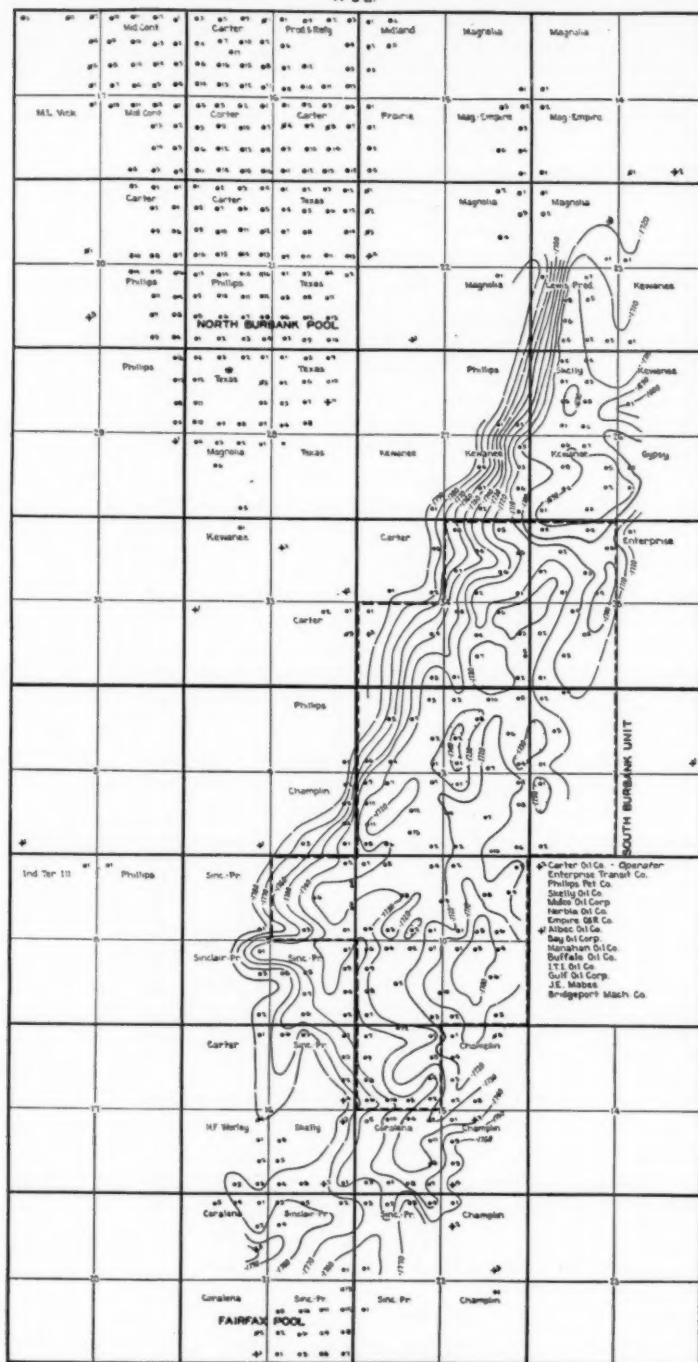
STRUCTURE OF "OSWEGO LIME"

The structure of the "Oswego lime" (Fig. 6) conforms generally to the attitude of both the top of the pay sand (Fig. 7) and the sandy shale (Fig. 8) member above. The coincidence is particularly striking along the east ridge and in the north end, the west ridge being less pronounced because it is less well preserved or developed. Structure contours on the base of the sand (Fig. 9) show that there is no parallelism between the base of the sand and the top of either the sandy shale or the sand, except on the small structure in the SW. $\frac{1}{4}$ of Sec. 26, T. 26 N., R. 6 E. (Figs. 9 and 10). Along the east ridge, in Secs. 3 and 10, T. 25 N., R. 6 E., which is the largest and best developed

[illegible]

FIG. 6

R 6 E.



SOUTH BURBANK POOL
CONTOURS ON TOP BURBANK SAND "PAY."
Contour Interval = 10 Ft.

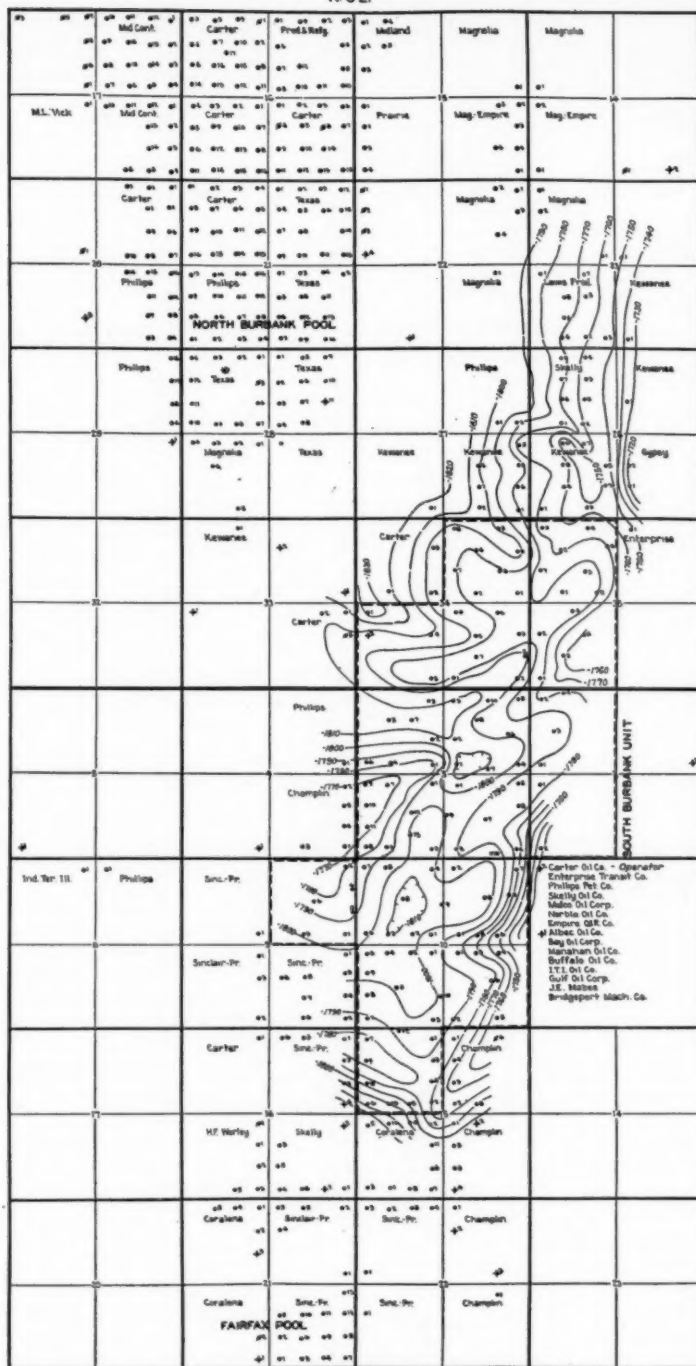
FIG. 7

R 6 E.



FIG. 8

R 8 E.

T.
26
N.T.
25
N.

SOUTH BURBANK POOL
 CONTOURS ON BASE OF BURBANK SAND.
 Contour Interval = 10 FT.

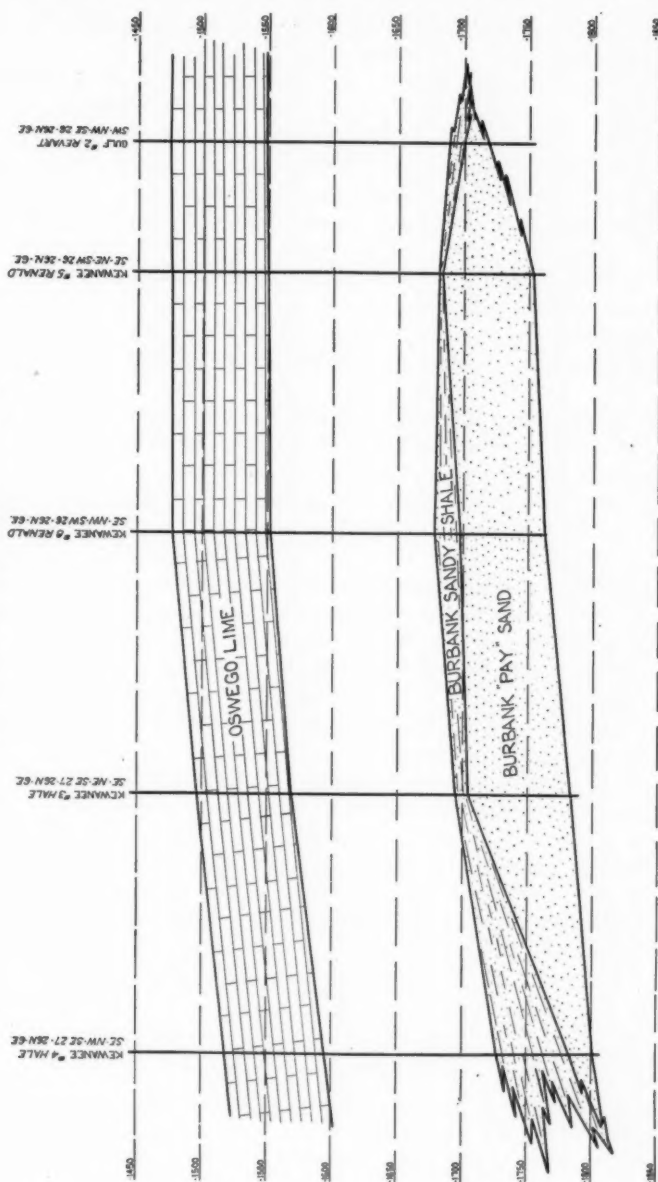
SOUTH BURBANK POOL
EAST-WEST CROSS-SECTION OF NORTH END

FIG. 10

ridge, the base of the sand is lower under the high part of the structure than it is under the lower part farther west.

Generally speaking, the base is an irregular plane dipping at the rate of about 40 feet per mile toward the west, which is about the regional dip on the surface. It is to be expected that the base of the sand would be irregular since these bars are laid down near shore, where the shore is subjected to many currents. This may account for the high area on the base of the sand in the SW. $\frac{1}{4}$ of Sec. 26, T. 26 N., R. 6 E.

Surface folding is found in the area,¹⁰ but does not reflect the structure over the ridges on top of the "Oswego lime." The surface structures are, however, reflected on the "Oswego lime" (Fig. 6), but strike at nearly right angles to the north-south ridges on top of the sand.

Compaction folds¹¹ as mapped on top of the "Oswego lime" are probably due to a combined draping effect and compaction of the Cherokee shale. Assuming that the "Oswego lime" was originally deposited on a nearly plane surface, the areas of thick sand would be areas of thin shale; the subsequent compaction due to loading and compression, with the loss of the free water, would be less than that over the areas where the sand was absent or thin. Athy¹² estimates that the compaction of shale under an overburden of 3,000 feet, which would be the minimum at South Burbank, would be about 40 per cent, and the compaction of sand about 5 per cent. This would easily account for the relief on the "Oswego lime" even after allowing 40 per cent for the thin limestones and sandstones in the upper part of the Cherokee shale.

The maximum relief on the top of the "pay" from the tops of the ridges to the trough is about 40 feet, while the maximum relief on top of the Oswego is about 27 feet. In general, structural relief on the Oswego is about 60 per cent of that on the sand.

On the east side of the pool, in Sec. 11, T. 25 N., R. 6 E., The Carter Oil Company's Barrett No. 1 was drilled to the "Mississippi lime" without encountering the Burbank sand. The Cherokee shale

¹⁰ C. F. Bowen, in David White and others, *op. cit.*, pp. 137-42, Pl. 21.

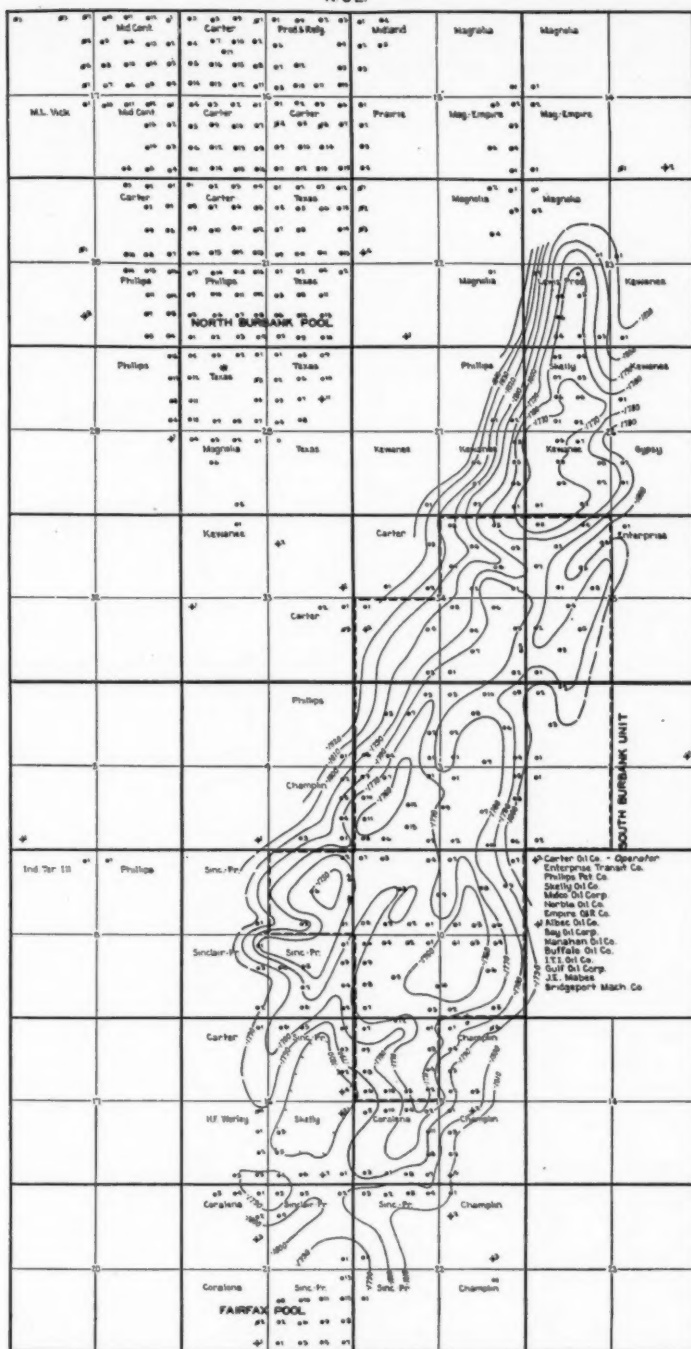
¹¹ H. D. Hedberg, "The Effect of Gravitational Compaction on the Structure of Sedimentary Rocks," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10, No. 11 (November, 1926), p. 1063. Discussion, Vol. 11, No. 8 (August, 1927), pp. 875-86.

P. D. Trask, "Compaction of Sediments," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 3 (March, 1931), pp. 271-76.

H. A. Ley, "Natural Gas in Eastern Kansas," *Geology of Natural Gas* (Symposium, Amer. Assoc. Petrol. Geol., 1935).

¹² L. F. Athy, "Density, Porosity, and Compaction of Sedimentary Rocks," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, No. 1 (January, 1930), p. 15.

R 6 E.



SOUTH BURBANK POOL
 CONTOURS ON TOP OF RESTORED BURBANK PAY.
 (After Correcting For Regional Dip)
 Contour Interval = 10 Ft.

FIG. 11

in this well is thinner than the interval from the base of the Oswego to the total depth in the well farther west, which did not drill through the sand and which has an unknown amount of sand and shale between the total depth and the top of the "Mississippi lime."

Several exceptions may be found in these generalizations, one of which is on The Carter Oil Company's Cook No. 3, Sec. 9, T. 25 N., R. 6 E., which found the "Oswego lime" high and the "pay" low. However, one compensates for this thin pay section by 72 feet of sandy shale above, which is composed largely of sand. This condition would no doubt account for many irregularities; poor logging would also account for some.

The top of the "Oswego lime" has been used as a marker rather than the base, as it is more readily and accurately logged by the driller; and in some areas, the base has several lime stringers below it which render accurate correlation difficult even where samples are available.

RESTORATION OF BAR

To better illustrate the shape of the sand lens immediately after deposition, a map has been prepared (Fig. 11) by removing the subsequent regional dip, which is about 40 feet to the mile, from the surface of the "pay" by mechanical methods. The correction should probably be somewhat greater because of the initial east dip during deposition, but this adequately illustrates the shape of the bar just before deposition of the sandy shale.

Restoring the "pay" to a level plane shows the sand dipping toward the base along the east side to give the sand body the bar shape which it theoretically should have. Figure 7 shows only a flattening along most of the pool. The growth ridges are accentuated and the base is about level in the restoration.

LABORATORY ORIENTATION OF WELL CORES BY THEIR MAGNETIC POLARITY¹

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ABSTRACT

A practical laboratory method of orienting well cores by their magnetic polarity was first developed by the Standard Oil Company of California's research department early in 1928. The procedure is designed to determine the original orientation in the ground of cores obtained in the ordinary rotary system of oil-well drilling, by identifying the north and south sides of a core, after it has been brought to the surface, through residual magnetic polarity in the heavy minerals of the rock. The writer describes the theory and the various steps in developing this idea from the original experimental machine to the commercial one which is self-recording by photographing the deflections of a light beam.

In conjunction with this magnetic core orienter a deviation corrector was developed. Directions of dip obtained from samples cored from crooked holes were worked out as apparent dips and strikes. The instrument, known as a deviation corrector, was designed to correct rapidly the apparent dip to the true dip, whenever the direction and degree of dip of the hole at the depth from which the core came are known. The instrument and mathematical computations are fully described in this paper.

PART I

MAGNETIC CORE ORIENTER

INTRODUCTION

During the summer of 1927 a magnetometer survey party, of which H. N. Herrick of the Standard Oil Company of California's research department and the writer were members, was working an area on the east side of the San Joaquin Valley in the proximity of an outcrop of gabbro. Because of the magnetic properties of the gabbro, the vertical intensity balance had been giving intensely high readings. A piece of gabbro was knocked off the outcrop and held against the north end of the magnetic system of the magnetometer. It was noticed that the needle reacted to this piece of rock in one direction, and upon turning the rock the magnetic system would react in another direction. This appeared to be certain proof that the gabbro, because of its high content of heavy minerals, was polarized. From this simple field experiment, the idea came to Herrick that heavy mineral particles in sedimentary rocks should also have polarity

¹ Read before the Association at the Los Angeles meeting, March 19, 1937. Manuscript received, March 3, 1937. Published by permission of the Standard Oil Company of California.

² Petroleum geologist, research and development department, Standard Oil Company of California.

and if a sensitive enough magnetic torsion balance could be constructed, the north and south sides of well cores could be determined.

Early in 1928, Herrick designed and built a magnetic torsion balance, unshielded from the earth's magnetic field. Application for patent on the magnetic method of orienting was filed May 14, 1928, Serial No. 277,729, and United States Patent No. 1,792,639 was issued February 17, 1931. Additional applications covering further developments are pending. The claims broadly cover the steps of taking a sample, determining its polarity, orienting it to correspond with its

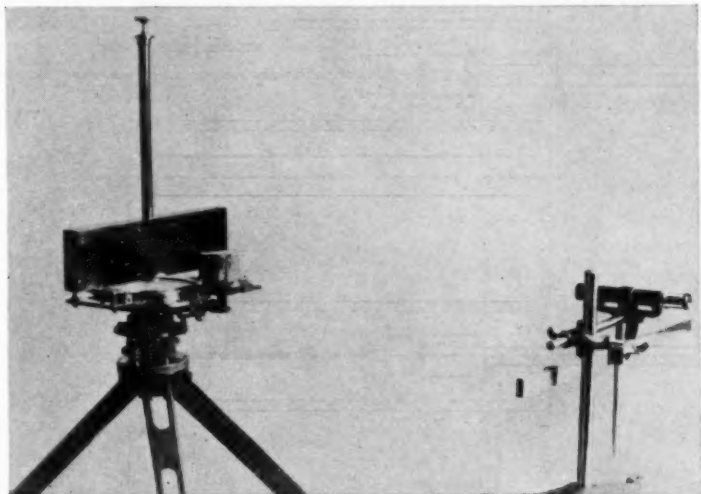


FIG. 1.—1928 magnetic core orienter, unshielded type without auxiliary magnets.

original position, and measuring the direction of the dip and strike of bedding indications.

Experiments carried on by the writer with this machine were very encouraging. The drawback, however, was that this type was not shielded from the earth's field and was too sensitive to outside interferences for operation in any but the most secluded localities (Fig. 1).

During the latter part of 1928, a shielded type of instrument, manually operated, was built. The immediate advantage of this type was evident from the beginning as the machine could be operated in the middle of an oil field, surrounded by steel derricks, and even adjoining a drilling well, without interference (Fig. 2).

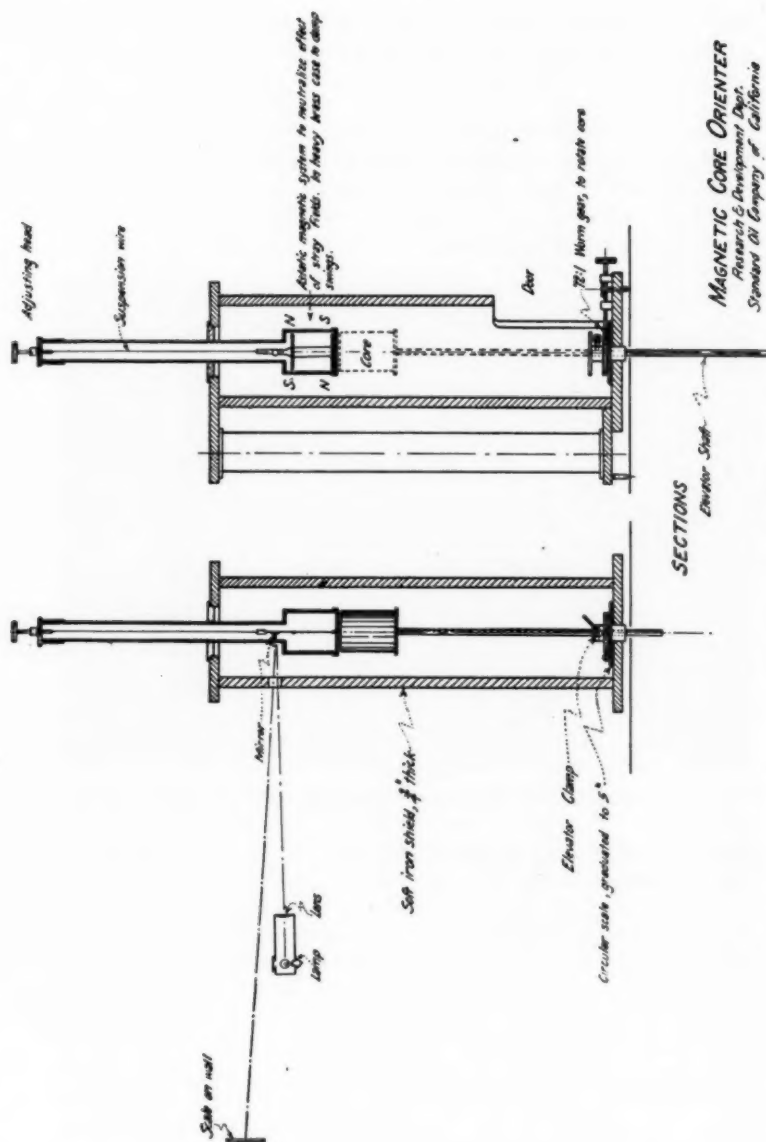


FIG. 2.—Cross-section, magnetic core orienter, 1928, shielded type, and manually operated.

From this type machine, experience brought about many improvements, such as the elevator assembly (Fig. 3) to replace the old method of raising the cores by hand, to the present improved type

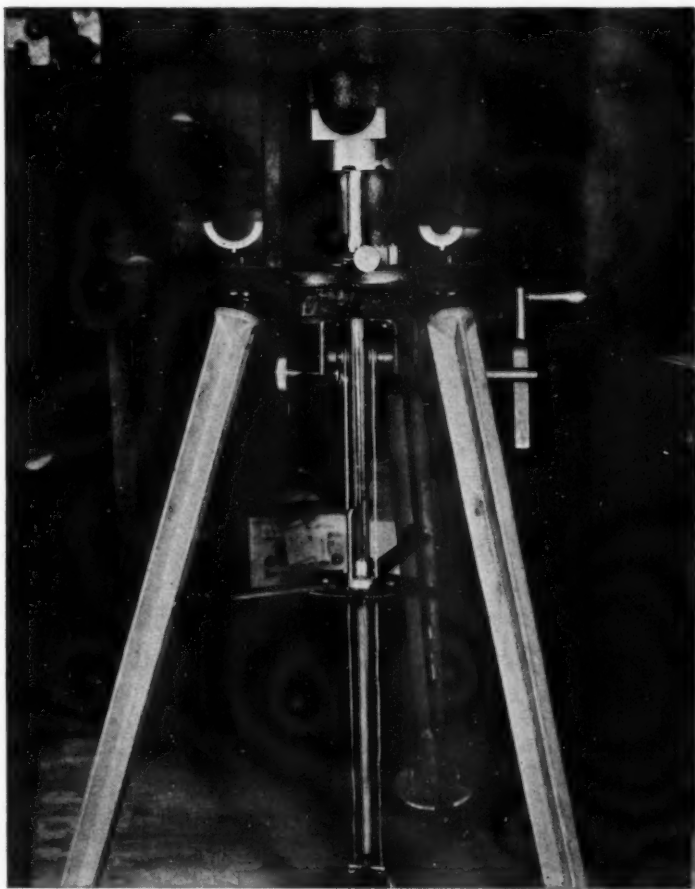


FIG. 3.—1935 magnetic core orienter, shielded and manually operated.
Bottom view.

whereby the deflections of the light beam caused by the polarity in the cores are registered on photographic paper.

Such improvements, both in the construction and operation of the machine and the interpretation of the resulting curves, have made

this method of orienting cores adaptable to commercial use and are adequately covered in issued and pending patents.

ACKNOWLEDGMENTS

For permission to publish the complete research work necessary for the development of the magnetic core orienter, the writer is indebted to officials of the Standard Oil Company of California, particularly to R. A. Halloran, manager of the research and development department, San Francisco, California; and to G. L. Kothny, vice-president of the Sperry Sun Well Surveying Company, licensee under the issued and pending patents covering all phases of the orienting procedure. H. N. Herrick has given much assistance in developing the theory, mechanical operation, interpretation of curves, and in the criticism of this paper.

For suggestions in the design of the first shielded type orienter, credit is given here to E. H. Zeitfuchs, J. F. Putnam, and J. R. MacGregor of the company's research laboratory at Richmond. Much valuable experimental work was done during the early stages of development of the machine by E. F. Griep of the research and development department.

The correct interpretation of results was greatly simplified by the furnishing of cores and their subsurface direction of dips by several of the company geologists, prominent among whom are W. S. W. Kew, H. L. Driver, R. G. Reese, L. W. LeRoy, and W. F. Barbat. Geologists from other companies have contributed materially by submitting cores from areas by which the magnetic orientation could be checked by other means. Among the latter are E. B. Hall of the Hall-Baker Company, for material from prospect core holes in the Santa Maria and Rancho Tejon districts; E. J. Bartosh of the Bankline Oil Company, for cores from the Wilmington and Shiells Canyon areas; L. S. Copelin of the Copelin Core Drill Company; E. L. Ickes and Max Krueger of the Western Gulf Oil Company; M. G. Edwards of the Shell Oil Company; N. A. Rousselot of the Milham Exploration Company; H. K. Armstrong; R. M. Barnes of the Continental Oil Company; and S. Grinsfelder of the Union Oil Company for cores from the Dominguez oil field.

R. L. Tallant of the Standard Oil Company's Los Angeles geological department is responsible for the picture of the machine and the selected curves. To W. M. Schaufelberger the writer is indebted for suggestions in the mechanical operation of the photographic orienter, and to H. C. Hill of the General Electric Company for furnishing the excellent magnets.

THEORY

It has been found that many mineral crystals in the igneous and plutonic rocks have a slight permanent magnetism, induced in them by the earth's magnetic field as the rocks cooled to below the "Curie Point." Agamemnone³ has claimed to have been able to determine the position of the magnetic north pole in various geological ages by observation of the polarity of such rocks.

As the older rocks are weathered and eroded away, the crystals composing them are freed, and, as some of these crystals have a weak magnetic polarity, there is a small directive force tending to keep their poles in the magnetic meridian. When such crystals are carried into bodies of water and laid down as sediments the settling particles, especially the finer ones composing clays and shales, on the average tend to be deposited with their magnetic axes in the earth's magnetic meridian. Fine particles have an almost frictionless suspension in water and settle very slowly so that they have ample opportunity to orient themselves in settling. Although many such crystals are forced out of line by interference with other grains, there should be a sufficient majority in the meridian to give a distinct polarity to many sedimentary rocks. In addition to this oriented settling of small magnetic grains during sedimentation in the case of the finer-grained rocks, the coarser grains as well as these finer crystal grains have been weakly magnetized in the plane of the earth's magnetic meridian through long standing in one structural position in the earth's field.

To determine the original orientation of a core, it should be necessary, therefore, only to provide an instrument sensitive enough to locate the magnetic north and south poles of the core. Having found these, the approximate magnetic variation at the geological period when the material was laid down could be determined from a sample of known orientation taken from an outcrop of the same formation. From these data, the meridian can be marked on the core, and the direction of dip obtained from the bedding shown in the core. However, for practical work, the procedure has been to disregard this magnetic variation of the particular geological age from which the core came, and apply only the correction for the area as found in the magnetic variation charts. As this method of orientation is believed to be only accurate to within 10° – 15° , the slight difference between the magnetic variation of the geological age of the core and the local variation at the well has been disregarded.

³ G. Agamemnone, *Estratto dal Boll. Sci. Sism. Ital.*, Vol. 8 (1903).

PREPARATION OF CORES

With the first machine (Fig. 4), the preparation of the core was a simple matter. The core sample was ground off square on both ends with sandpaper, not emery paper which is magnetic. All magnetic particles and rotary mud were sandpapered off the sides of the core. An arbitrary reference mark was then made on the sides of the core.

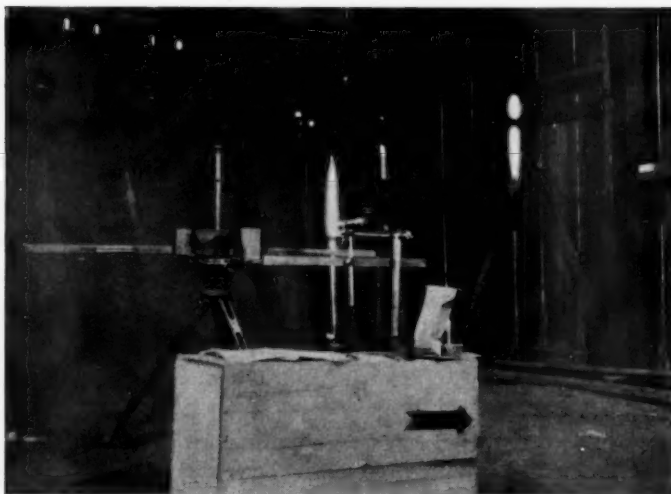


FIG. 4.—1928 magnetic core orienter, unshielded type, with auxiliary magnets.

A similar procedure was used in preparing cores for the shielded type of magnetic core orienter (Figs. 2 and 5), except that the ends of the core were cut square to the vertical axis of the core by means of a thin carborundum wheel. The length or depth of the core could be any convenient size as the machine worked on the top and bottom faces of the core. The sides of the core were also carefully cleaned of any foreign matter by sandpapering.

During the latest stages of development, when cores were held horizontally and rotated 360 degrees, the preparation of the cores became a more exact science. Whether the core was to be rotated by hand or rotated mechanically, the sides of the core had to be smoothed and the whole core made into as near a true cylinder as possible. The rough core from the well was first marked with an arrow pointing toward the top of the hole and then examined for bedding planes. If

the only bedding planes were those on the two ends of the core, it was necessary to transfer by any convenient distinguishing mark on to the sides of the core the high point of the bedding plane and at

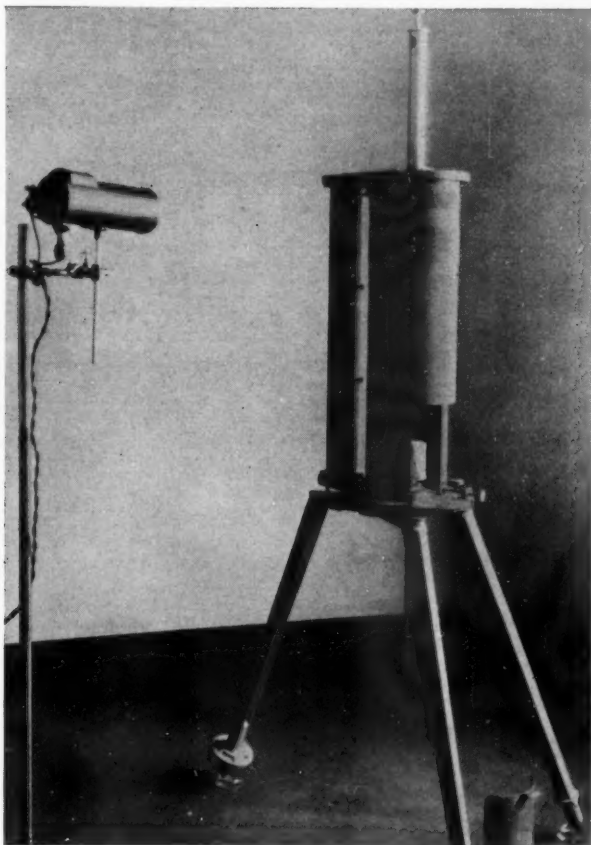


FIG. 5.—1928 magnetic core orienter, shielded type, and manually operated.

180 degrees from this on the other side of the core the lowest point of the bed. Upon cutting off the ends of the core and the subsequent loss of the bedding planes, the distinguishing marks are then transferred to the top of the core prior to smoothing the sides. If one or several bedding planes are visible in the core itself, the cutting-off process of

the ends can then be made without loss of the all-important dip and strike.

Because of the limiting inner diameter of the round shield the total maximum length of the core was limited to 3 inches and the diameter to not more than 5 inches and not less than 2 inches. The

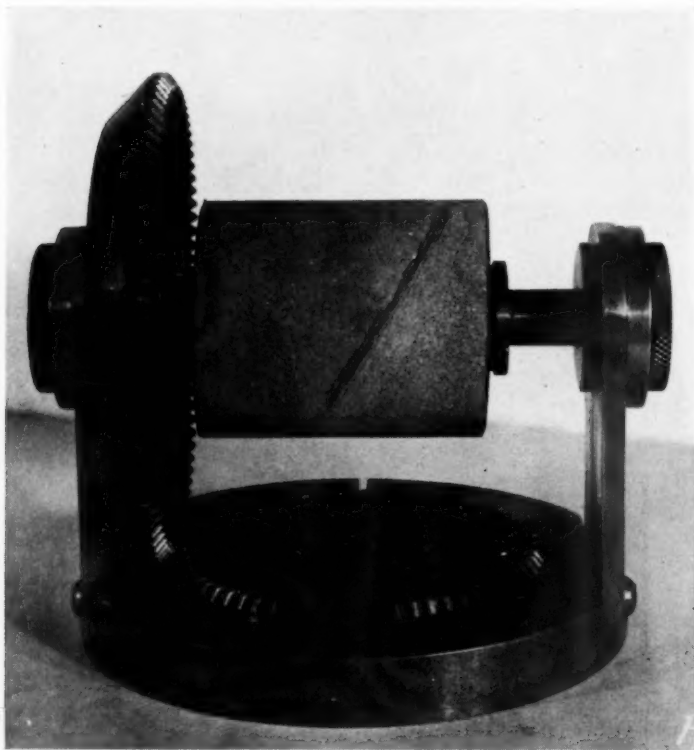


FIG. 6.—Core holder.

ends of the core are then accurately centered, the top surface of the core having a single hole drilled into it to a depth of about $\frac{1}{2}$ inch and the bottom surface being likewise drilled and centered, with an additional small hole into which is inserted the driving pin of the core holder (Fig. 6).

DESCRIPTION OF MACHINES

1928 MACHINE—UNSHIELDED TYPE

The first instrument designed for this work consisted of a long, powerful, permanent magnet, suspended horizontally by a fine filar suspension at its center. This magnet was placed in a weak magnetic field by reducing the earth's field by auxiliary fixed magnets (Fig. 4) arranged to reduce the earth's field to zero in the vicinity of the main magnet.

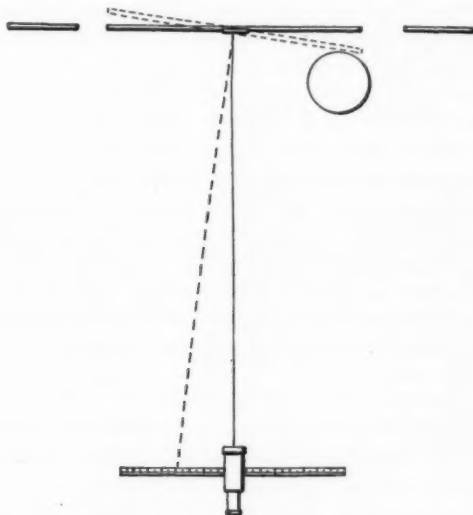


FIG. 7.—Core orienter.

A rotating stage was provided near the north-seeking end of the suspended magnet, by means of which a section of core could be supported with any part of its circumference next to the magnet.

The core was examined by noting the amount of attraction or repulsion of the suspended magnet at each 30° around the core. The amount of movement of the magnet was read by observing with a telescope the reflection of a fixed scale in a mirror attached to the suspended magnet (Fig. 7).

As the core was placed near the north-pointing end of the magnet, the position of maximum attraction is the south magnetic pole of the core. This point is located, and the magnetic axis is scribed on top of the section of core.

Tests.—The instrument was set up in an old barn about 4 miles north of Whittier, California, a location chosen so as to be as far as possible from the magnetic effect of the Pacific Electric Railway and other sources of disturbance. Since the instrument was extremely sensitive, it was not possible to avoid interference even there, and it was necessary to suspend work whenever a car was passing on the Pacific Electric line, 3 miles north of the station.

A supply of cores for tests was gathered from the more recent wells in the Los Angeles Basin and from core holes at Montalvo, Ventura County. The ends of sections a few inches in length were squared off by rubbing them on a sanded slab of concrete. It was impracticable and dangerous to cut them with a hacksaw, as the blades were dulled almost immediately, with the risk of leaving on the cores minute pieces of steel worn from the blades. The sides of the samples were also rubbed down with sand to remove rotary mud and any possible fragments of steel from the drilling bit.

Since the cores were of different diameters, the scale on the core stage was not used. The core holder was covered by a piece of pasteboard with an index line marked on it, and marks were made on the cores at 30° intervals around its lower edge, any one of which could be placed opposite the index. The edge of the core was placed in direct contact with the instrument box on every 30° reading, which gave a constant distance from core to magnet.

The instrument was set up first as shown in Figure 1. With this arrangement, deflections could not be obtained from any of the cores. It was evident that the earth's field was holding the magnet in line so strongly that the small force due to the core could not deflect it. Therefore, an auxiliary magnet was added at each end of the instrument, so arranged as to weaken the earth's field. The ends of the auxiliary magnets, tending to repel the adjacent pole of the large swinging magnet, were placed nearest the instrument and moved toward it until the swinging magnet would barely stay in line—a slight further movement of the auxiliary magnets would throw the main magnet over against its case. This arrangement increased the sensitiveness of the device enormously and very distinct results were obtained from most of the cores tested, even those $2\frac{3}{8}$ inches in diameter.

When readings had been taken at each of the marks on the core, the values were plotted on cross-section paper and the point of maximum attraction located. Since the core stage is at the north-pointing end of the magnet, maximum attraction is at the unlike (south) pole of the core.

Results.—The orientations made with this early type of instrument were checked so far as possible with dips known by structure contours at the locations of the wells from which the cores were taken. The encouraging results obtained furthered the continuance of this work.

As it would not be possible to list all the cores tested, a few of the results as well as some of the curves are given here.

TABLE I

Well	Depth in Feet	Strike of Bedding Plane		Difference
		Orienting D.P. Out	Core Orienter	
Saticoy Citrus No. 1.....	324	N. 80° E.	N. 85° E.	5° R
Saticoy Citrus No. 1.....	326	N. 17° W.	N. 26° W.	9° L
Haydock No. 1.....	985	N. 51° E.	N. 45° E.	6° L
McGrath No. 1.....	473	E-W	N. 80° E.	10° L

The greatest divergence between the two methods was 10°. Apparently, the magnetic variation to be used for formation is about 7° larger than present surface value, since the errors average about that amount counterclockwise. It is also interesting that the first two cores are only 2 feet apart in the same hole, yet they have very different strikes and dips, checked by both methods of orientation. Evidently, it is necessary to test many cores from each well to get the most accurate average values.

TABLE II

Well	Depth in Feet	Degree of Dip	Direction of Dip of Bedding Plane		Material	Figure
			Subsurface Contour	Core Orienter		
Baldwin No. 71.....	3,376	34°	South	South	Shale	8
Baldwin No. 71.....	3,415	20°	South	S. 10° E.	Sand	9
Benedictine No. 1....	3,680	30°	S. 40° W.	S. 10° W.	Sandstone	10
Benedictine No. 2....	3,768	20°	S. 25° W.	Southwesterly	Shale	11

1928 MACHINE—SHIELDED TYPE

(For use on top and bottom of cores)

The simple form of the instrument described previously gave very promising indications. It was, however, so severely influenced by temperature changes and stray fields from sources external to the instrument, that the problem had to be attacked from a different angle before its practical value could be defined. Since it was evident that the balance must be shielded from these outside influences, it was completely redesigned and rebuilt.

This shielded type of orienter is shown in Figures 2 and 5. The changes from the original type as shown in Figure 4 are as follows.

1. The suspended magnetic system was made "astatic," that is, to consist of two equal magnets, one above the other, and placed in opposite directions. With this arrangement the effect of a stray magnetic field from a distant source is balanced out, since the effect on the upper magnet is equal and opposite to that on the lower, as the source of a distant disturbance is about the same distance from both magnets. The core, being placed close to the lower magnet, has an unbalanced effect on it since the upper magnet is many times more distant from the core than the lower.

2. Since it proved practically impossible to get the suspended magnets of exactly equal strength, a heavy iron shield was provided for the whole instrument, to shut out both the earth's field and stray fields. This gave assurance that only actual permanent magnetism of the core was affecting the system, since the earth's field was not present to induce magnetism in it. It also left the torsion wire suspension as the only directive force for the suspended magnetic system, thus greatly increasing the sensitiveness of the instrument.

3. In order to save space and reduce the weight of the shield, the cores were presented to the swinging magnets end on instead of being placed beside them as was done with the original instrument. This gave a different form of deflection curve as the core was rotated under the magnets; a rapid change in deflection from right to left or the reverse now occurred when a pole of the core passed under a pole of the magnet.

4. To avoid the inconvenience of reading through a telescope, a spot of light was reflected from the mirror just above the magnetic system to a scale on the wall.

5. Since the iron shield gradually takes on a slight magnetic polarity from the earth's field through long standing in one position, *et cetera*, a coil has been placed on it so that it can be demagnetized occasionally by sending an alternating current through the coil for a moment, care being taken that the magnetic system has been previously removed from the shield. This coil is not used in operation of the instrument and is only an emergency attachment. The resistance coil along one side of the instrument permits the use of 110-volt lighting current for this purpose.

Operation.—The core sample was cut off square on both ends by means of a carborundum wheel. Any foreign magnetic particles were sandpapered off the sides of the core. An arbitrary reference mark was made on the side of the core, and it was placed centrally and

level on the elevator of the previously leveled instrument, with the reference line opposite zero of the circular scale. The elevator was raised by hand until the top of the core struck the underside of the magnet box. It was then lowered until the core cleared the box and the core rotated by 20° steps, noting deflections of the reflected spot of light at each position. These deflections were plotted on cross-section paper, and the resulting curve compared with a standard curve made from tests on samples of known orientation to locate the position of the north and south poles of the core with reference to the zero of the circular scale and a mark on the side of the core. The magnetic meridian was then marked on top of the core, magnetic variation set off, and the direction of dip determined from this and the bedding shown in the core.

Tests.—From the large number of cores tested with this type machine, it was quite evident that many of the cores had very marked magnetic polarity and the polarity on the cores of known orientation appeared to correspond roughly with the magnetic meridian. Several cores tested were too weak in polarity to show results, at least under interference conditions at the afore-mentioned set-up, and some of the curves were ambiguous owing to secondary minerals such as pyrite occurring irregularly in the cores. It was decided that under the subject method, the device could not be expected to work on every core tried, but by testing several cores from the same well, definite results within reasonable limits would probably be given by perhaps a third of the total number. Since a determination took only about a half hour, even testing a dozen cores from one well would be less expensive than other known methods.

Results.—Laboratory determinations of the orientation of several cores are shown on the combined sheet in Figure 12, which shows the deflection curves for these cores. Deflections are in inches at 12-foot distances.

MAGNETIC CORE ORIENTER TESTS ON ORIENTED HAND SAMPLES

In 1931 the previously described machine was installed in the laboratory at Santa Fe Springs, shielded and secluded from outside interferences. It was decided at this time to make further tests of the machine on the top surface of core samples obtained from outcrops of known orientation and at the same time to make a magnetic susceptibility test on each sample in an attempt to determine the relation between cores of low magnetic susceptibility and their magnetic polarity. In other words, an attempt was made to draw a line be-

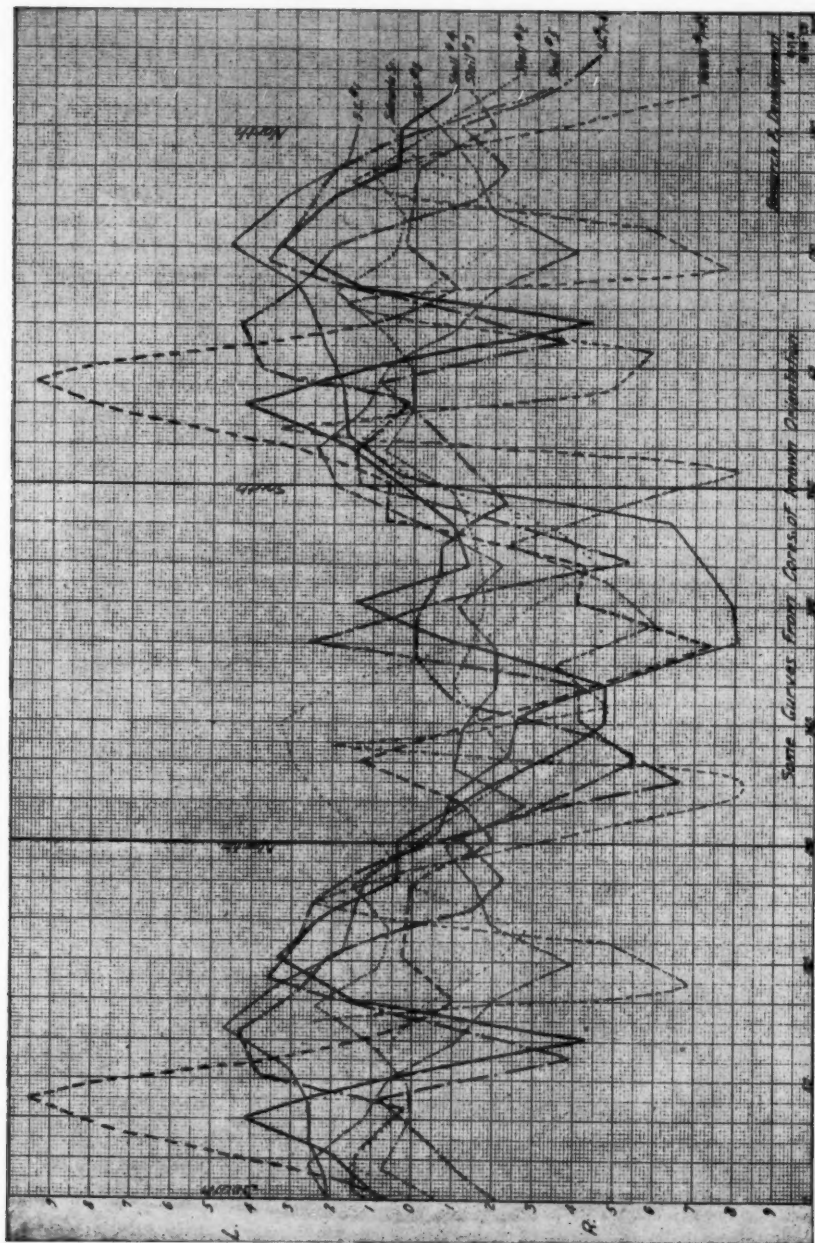


FIG. 12.—Curves from cores of known orientation.

tween cores that gave sufficient deflections for orienting and those that gave no or very little deflection.

Previously it was found in practice that many oil-well cores of very weak magnetic properties had a definite polarity. It was possible to test these cores several times in the magnetic core orienter and get the same general characteristic curve which crossed the polar axis four times. It also was of interest to determine if inclination of the core—that is, cores from crooked holes—had any effect on the characteristic curve of the core when tested in the magnetic core orienter.

The relation between magnetic susceptibility and polarity was of importance as cores with a low susceptibility had very little polarity and a great deal of time and work could be saved by determining the susceptibility of the cores and discarding those with low values.

Oriented hand samples for these tests were collected in the Los Angeles Basin, Santa Ana Mountains, Sespe Creek, San Fernando Valley, Kettleman Hills, and the San Joaquin Valley. They varied in age from the Cretaceous to the Pliocene, and the magnetic susceptibility ranged from 3600×10^{-6} to 5×10^{-6} . The samples were oriented in the field with a Brunton compass and were cut and shaped in the laboratory. Each sample was tested at least twice, using different reference marks. If the curves obtained from the two tests did not coincide when shifted the angular distance between the two reference marks, the sample was discarded. Each sample was shaped like a cylinder and the ends cut parallel with the earth's surface without regard to the dip of the outcrop, just as it would have been cut underground by a core bit.

Results.—Using the top of the samples only, it was found that approximately 75 per cent of them had a definite polarity and that about 50 per cent were easily oriented. About 25 per cent of the samples had no polarity, and it was impossible to orient them. These samples were mostly Monterey shale (Miocene), Pico-Fernando shale (Pliocene), and Sespe sandstone of the Coldwater series (Oligocene age). A few samples were broken in cutting and had to be discarded.

The samples of high magnetic susceptibility were very easily oriented, and this orientation checked closely with that obtained in the field. Samples with a susceptibility of 150×10^{-6} and over were easily and accurately oriented. Samples with a susceptibility of 30×10^{-6} to 150×10^{-6} were oriented with a less degree of accuracy, although they had definite polarity. It is believed inadvisable to attempt to orient samples whose susceptibility is less than 30×10^{-6} as the results are apt to be inaccurate and in most cases can not be duplicated.

A 3-inch disk of sheet iron was weakly magnetized and tests were made to determine the effect of inclination of the magnetic axis on the characteristic curves when examined in the magnetic core orienter. The disk was inclined at various angles ranging from 10° to 40° with either the north or south pole of the magnet uppermost. Apparently the inclination of the sheet iron magnet did not change the characteristic curve and had no effect on the orientation of the magnet. This was an important point in the tests because of the possible effect of steeply dipping beds, 60° - 90° on the orientation of a core. Furthermore, it was possible to determine the poles of the circular disk with a far greater degree of accuracy with the core orienter than with a compass needle. This same inclination test was also made on a thin sample of sandstone from Kettleman Hills and appeared to have no effect on the orientation of the sample. However, this may not be strictly true for samples of very low susceptibility.

From these control tests, the following conclusions were reached.

1. It was possible to orient core samples and hand samples whose susceptibility is 150×10^{-6} or more with fair accuracy.

2. Samples with susceptibility of 30×10^{-6} to 150×10^{-6} have, in most cases, a definite polarity and can be oriented successfully, especially where several samples have been taken.

3. The effect of degree of dip on the polarity of cores was found to be of little importance on cores of strong polarity and had no effect on the ability of the core orienter to orient the sample.

4. No attempts should be made to orient cores of very low susceptibility.

5. Work with hand samples of known orientation indicated that many rocks have permanent magnetism approximately in the earth's magnetic meridian which they retain for at least several years after collection.

Table III gives a comparison between samples oriented in place in the field and the same samples oriented by the magnetic core orienter.

Table III indicates that the magnetic method will orient cores by using the top of the core only and will check the true conditions 3° - 20° , with the majority checking 3° - 7° . On the basis of this work it was felt that magnetic orientations within a limit of error of 15° would be possible.

Figure 13 shows a variety of curves obtained from cores of different formations. These show the general shape of the curve to be expected when cores are presented end on below the magnetic system and in some instances indicate the strength of the residual magnetism in-

TABLE III
HAND ORIENTED SAMPLES

Sample No.	Material	Susceptibility	Degree of Dip	Field Orientation		Orientation by Magnetic Core Orienter Direction of Dip	Difference	
				Strike	Direction of Dip		Clockwise	Anti-Clockwise
1	Puente Hills sandstone	33.9×10^{-4}	42°	E-W.	South	S. 20° W.	20°	4°
2	Puente Hills sandstone	33.9×10^{-4}	54°	N. 72° W.	S. 18° W.	S. 14° W.		3°
4	Puente Hills sandstone	26.4×10^{-4}	44°	N. 70° W.	S. 20° W.	S. 17° W.		3°
6	Olive Hills Temblor sandstone	17.9×10^{-4}	11°	N. 32° E.	S. 58° W.	S. 53° W.		5°
8	Olive Hills Monterey shale	32.6×10^{-4}	46°	N. 52° E.	N. 38° W.	N. 43° W.		4°
9	Moorpark Sespe sandstone	33.9×10^{-4}	21°	N. 50° E.	N. 40° W.	N. 56° W.		16°
12	Santa Susana Cretaceous shale	17.9×10^{-4}	25°	E-W.	South	N. 47° W.		3°
17	Santa Susana Cretaceous shale	1442.7×10^{-4}	29°	N. 84° E.	S. 6° E.	S. 11° E.	3°	11°
18	Santa Susana Cretaceous shale	512.9×10^{-4}	30°	N. 85° W.	S. 5° W.	S. 3° E.		16°
19	Santa Susana Sespe sandstone	24.0×10^{-4}	24°	N. 7° W.	S. 85° W.	S. 88° W.		
20	Coldwater Series Sespe sandstone	20.3×10^{-4}	30°	N. 24° W.	N. 66° E.	S. 11° E.	3°	
25	Kettleman Vivianitic sandstone	3366.3×10^{-4}		N. 85° W.	N. 5° E.	N. 73° E.	5°	
26	Kettleman Vivianitic sandstone	3286.1×10^{-4}		N. 85° W.	N. 5° E.	N. 8° E.	7°	
27	Kettleman Vivianitic sandstone	3066.0×10^{-4}		N. 80° W.	S. 10° E.	N. 5° W.	3°	
28	Sec. 28, T. 22 S., R. 18 E.	3326.0×10^{-4}		N. 8° E.	S. 86° E.	S. 83° E.		15°
32	Pinole tuff	501.0×10^{-4}	10°	N. 8° W.	N. 82° E.	N. 85° E.		3°
34	San Pablo cross-bedded sandstone	3206.0×10^{-4}	35°	N. 35° W.	N. 51° E.	N. 68° E.		13°
37	Suisun sandstone	3366.3×10^{-4}	12°	E-W.	South	S. 20° W.	20°	

herent in certain types of formations. This figure also compares the location of magnetic north as determined by the core orienter with magnetic north on the core as actually located on the sample in the field.

ORIENTATIONS ON TOPS AND BOTTOMS OF CORES

Following the previously described experiments on hand-oriented samples from the field, it was decided to orient cores by locating the north and south poles on both the top and bottom of each core. This procedure should give a check as the two opposite curves should localize the north and south poles in approximately the same place on the curves.

The experimental work on tops and bottoms of cores was continued until the end of 1934, during which time many cores were run with varying success. This lack of success was due mainly to the small amount of polarity in the cores. It was found that less than 50 per cent of the cores secured during this period had sufficient polarity to give a curve on which the south or north poles could be located.

Attempts were made to increase the sensitivity of the machine by using different types of magnets. Magnets of cobalt-, tungsten-, carbon-steel, *et cetera*, were tried with no improvement. The magnetic system was even changed by suspending the two magnets astatically in a vertical instead of horizontal position. The vertical magnets decreased the sensitivity of the machine to a greater degree so this method was soon abandoned. Finally an excellent magnet steel with ability to retain a maximum amount of magnetism for a long period was obtained from the General Electric Company and is in use to-day.

Most cores with good polarity gave excellent curves which were interpreted successfully, but these curves were not numerous enough to do justice to this method of orienting. Such type curves are shown in Figure 14.

It was found that if many cores from the same well were oriented, a sufficient percentage of them would have enough polarity so that a fair average of direction of dip could be determined.

Such a set of cores was obtained from the Milham Exploration Company's Connolly No. 1, drilled on the Tracy anticline, Sec. 5, T. 4 S., R. 5 E., M.D.M. All the cores were from the Cretaceous, most of them composed of sandy shales. They totalled 16 cores ranging from depths of 1,874 to 5,228 feet. Out of these, 8 checked within the limits of error. The balance was thrown out for various reasons, such as being too erratic, having poor bedding, weak polarization, shale inclusions in the sandstone which gave false readings, *et cetera*.

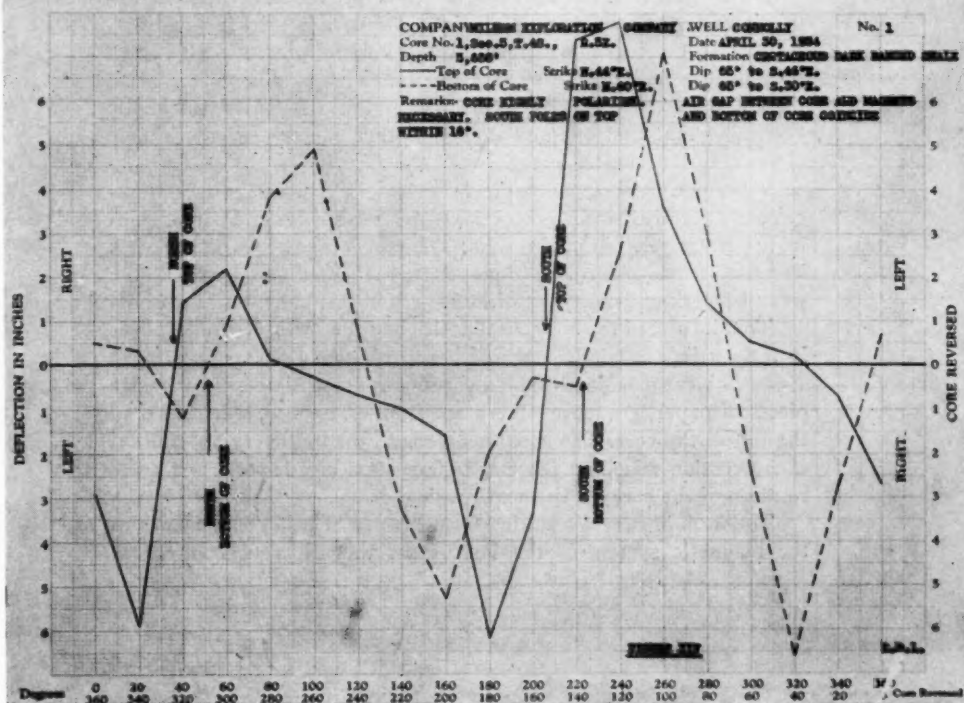
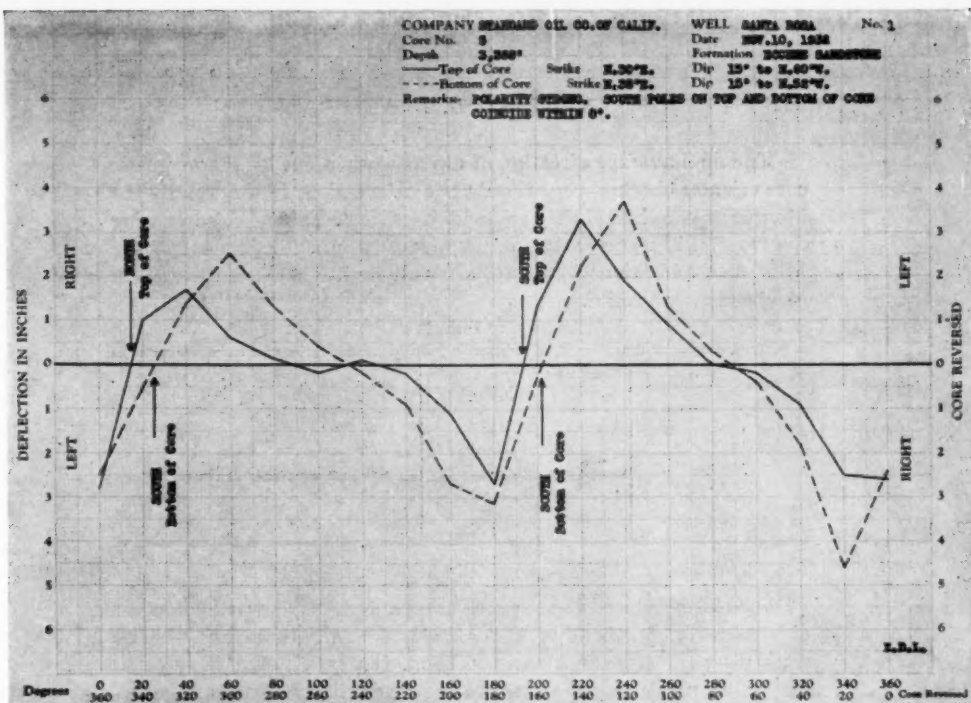


FIG. 14.—Type curves on tops and bottoms of cores.

The final average direction of dip as worked out by the magnetic core orienter checked very closely two orientations in the well by the Macready core barrel at 5,205 and 5,228 feet. Table IV, comparing the results, is made from data supplied by N. A. Rousselot of the Milham Exploration Company, after all results had been turned in independently to him.

TABLE IV

<i>Core Depth in Feet</i>	<i>Magnetic Core Orienter Average Direction of Dip</i>	<i>Macready Core Barrel Direction of Dip</i>
5 cores 1874-2920	S. 11° E.	
3638	S. 38° E.	
5025	S. 19° E.	S. 29° E. Not considered reliable
5228	S. 19° E.	S. 24° E. Perfect conditions
Average of 8 cores	S. 29° E.	S. 26° E. Average

1935 MACHINE—SHIELDED AND MANUALLY OPERATED TYPE

For reasons stated in the preceding paragraphs, it was found that only about 50 per cent of the cores had sufficient polarity to be worked by the top and bottom method. It was felt that some other method of presenting the cores to the magnetic system must be devised if the instrument was to have economic value.

As the magnetic lines of force enter the ground at an angle of approximately 60°, the magnetic axis in the core is then inclined 60°. By placing the core in a horizontal position and presenting it in this position to the magnetic system, the polar axis of the core is positioned to be substantially parallel with the axis of the magnetic system so that first one and then the other effective magnetic pole of the core is presented parallel with the effective length of the magnetic system. Such a procedure immediately resulted in greatly increased deflection readings on weakly polarized cores and correspondingly greater reliability of results. The percentage of workable cores increased from 50 per cent to 90 per cent, the balance still being too weak to work under any conditions.

To take care of the horizontal position of the cores, certain changes in the carrier of the old machine had to be made (Fig. 15). Several V-blocks were machined to hold cores of varying diameters. Circular pieces of paper, graduated every 20° from 0° to 360°, were glued to the top of the core. The core was turned by hand every 20° and on each occasion raised to the magnetic system and lowered for a 20° rotation of the core for the next reading.

The form of curves resulting from the new relation of the cores to the magnetic system of the instrument was different from those

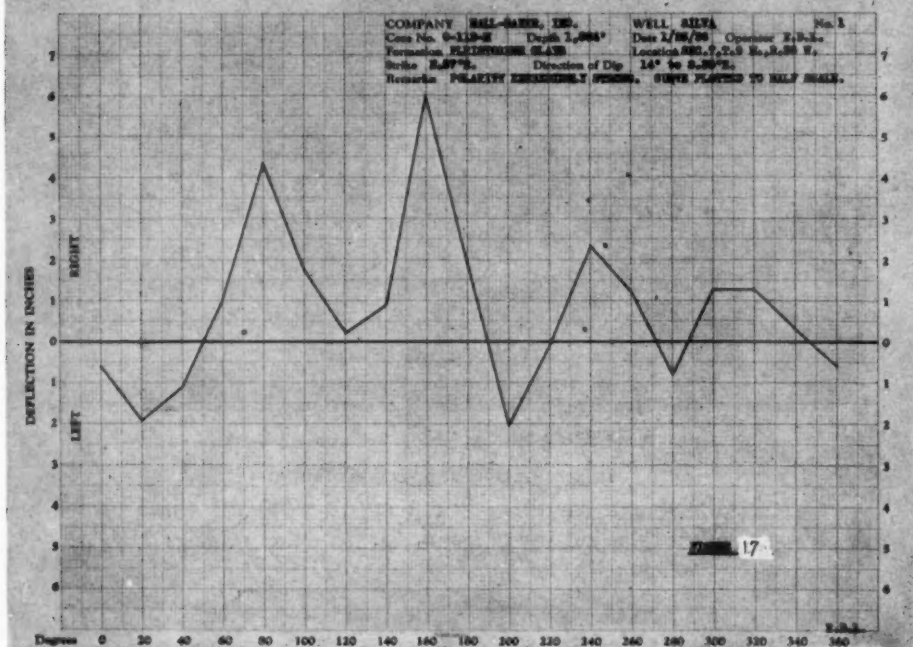
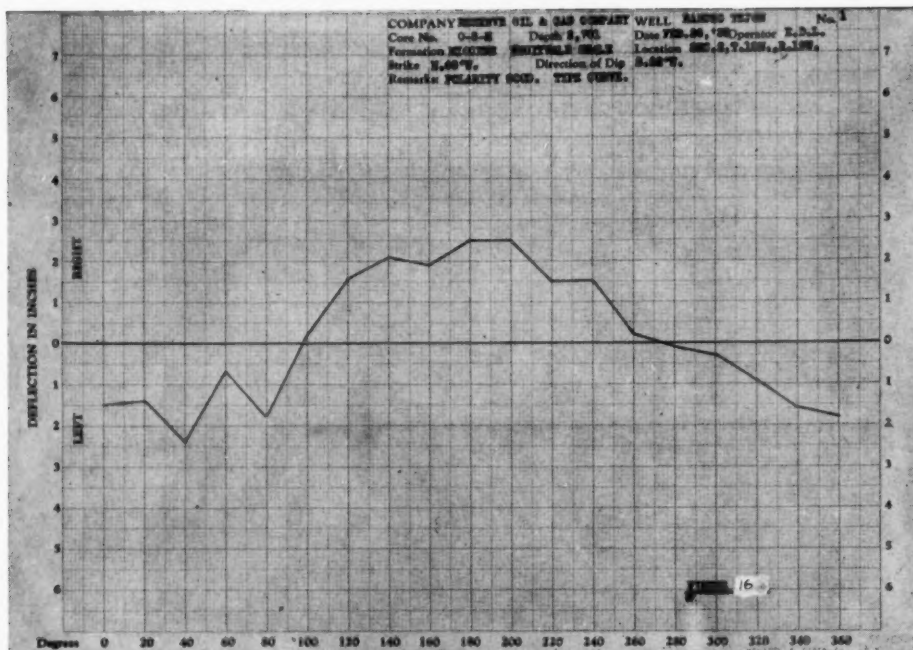
given in the end-on position. Typical curves are shown in Figures 16 and 17.



FIG. 15.—1935 magnetic core orienter, shielded and manually operated.

1936 MACHINE—SHIELDED AND SELF-RECORDING

On the whole, satisfactory results were obtained with the manually-operated machine but it was found that deflection readings at



FIGS. 16 and 17.—Typical curves with cores in horizontal position.

20° intervals were not sufficiently accurate, as the exact high and low points on the curves were sometimes passed over between the 20°

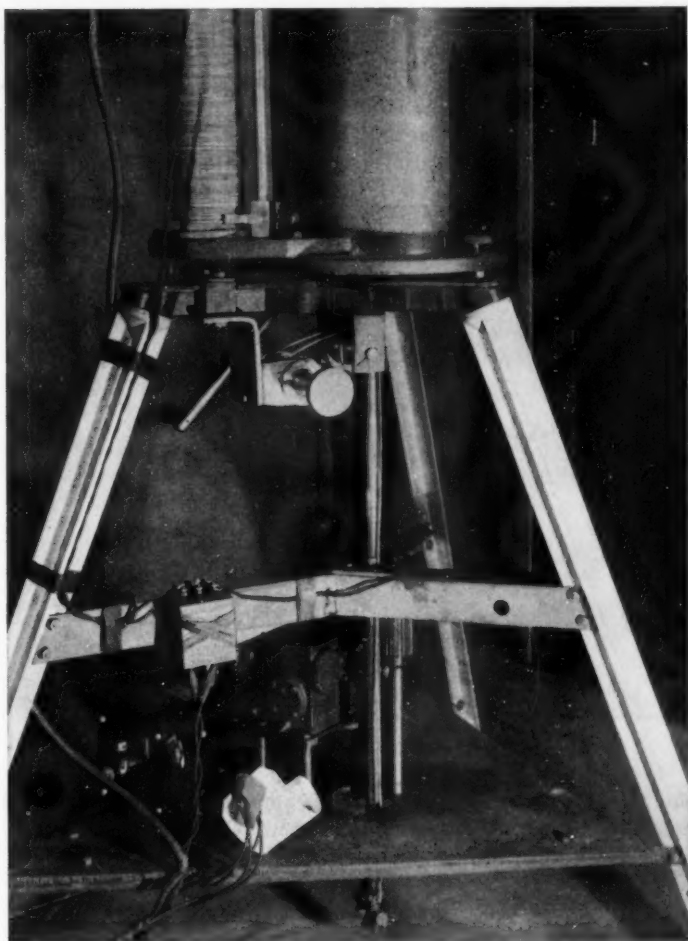


FIG. 18.—View of 1936 machine, showing driving mechanism.

readings. When such critical points were lacking, it was necessary to rerun the core at 10° intervals with an occasional 5° reading. This lengthened the time of operation from approximately 45 minutes at

20° intervals to 2 hours at the 10° and 5° intervals. In addition, the resulting curves at such intervals had a "saw-tooth" effect, and most important, only a part of the material in the core was being tested. By installing continuous rotation of the core at slow speed below the magnetic system, the resultant curves would be a picture of all the polarized surface of the core and they should be materially smoother.

With this idea in mind, the 1936 machine was completely revamped except for the magnetic system and the shield. Figure 18 shows the driving mechanism below the shield and Figure 19 the

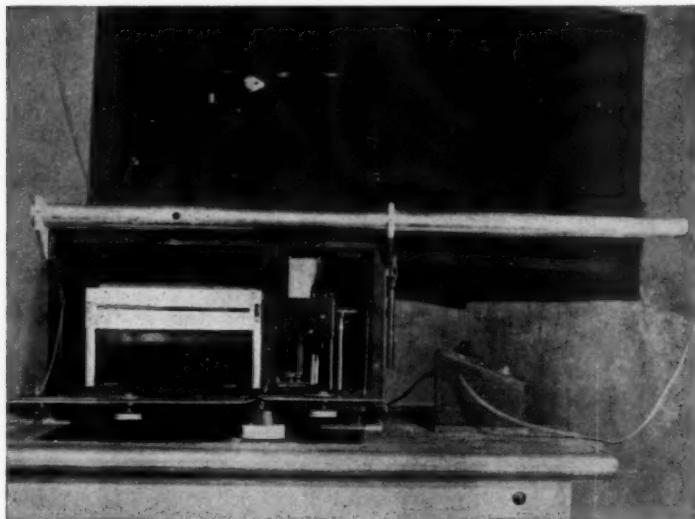


FIG. 19.—Photographic recording drum of 1936 machine.

photographic recording drum which is approximately 6 feet distant from the instrument. A specially designed holder was made to hold the core, which could be adjusted to center the core below the center of the magnets (Fig. 6).

With this new procedure it was necessary to prepare the core more carefully. In addition to squaring the ends, the core had to be drilled on both ends so that it could be supported and centered in the holder, and the sides of the core had to be perfectly smoothed with a carborundum wheel in a lathe. When this operation was completed, the core was as near a perfect cylinder as could be made.

The driving mechanism, shown in Figure 18, below the shield,

consisted of a General Electric synchronous motor. As it was planned to rotate the core to make one complete revolution in one-half hour, it was necessary to provide a set of reduction gears. These gears were meshed with a vertical drive shaft which in turn rotated the core holder. A long gear on the bottom of this vertical shaft took care of cores of varying diameters.

The recording drum, on which is placed bromide contact paper, is clock driven; a set of gears between the clock and the drum turned the drum one revolution in a half hour so that the drum and the core were synchronized. A switch at the recording drum engaged the drum gears with the clock simultaneously with starting the synchronous motor and the rotation of the core.

The light beam arrangement is mounted on the drum. The light is thrown on a small aluminized mirror on the magnetic system and reflected through two lenses to a pin point on the drum.

After placing the core in a holder and bromide paper on the drum, a starting line is photographed on the paper by moving the core slightly up and down below the magnetic system. This causes the light beam to travel horizontally. Everything then being in position, both drum and core, the operation is started by means of throwing the switch, which causes the drum and the core to start rotating at the same time. A complete revolution of the drum and the core takes approximately 30 minutes, during which time the light beam travels back and forth, its range depending on the polarity of the core. After a complete revolution of the core, a warning bell rings, which enables the operator to throw out the switch and close the recorder window, thus shutting off the light beam on the drum. An end line at 360° is also photographed while the core is being slowly lowered. On developing the bromide paper, a curve results, which is then interpreted for location of south and north poles.

Using this procedure, approximately 600 cores have been run with excellent results, over 90 per cent of them having sufficient polarity for a determinable curve. The curves, however, vary as to their regularity depending on the nature of the material. A perfectly homogeneous core will give a type curve as shown in Figure 20, while one with crystals of varying sizes will give the curve shown in Figure 21.

CONCLUSIONS

Sufficient experimental work has been accomplished during the past few years to demonstrate that cores can be correctly oriented in the laboratory by means of their polarity, provided the top of the core is known and correctly marked. Many cores have been submitted

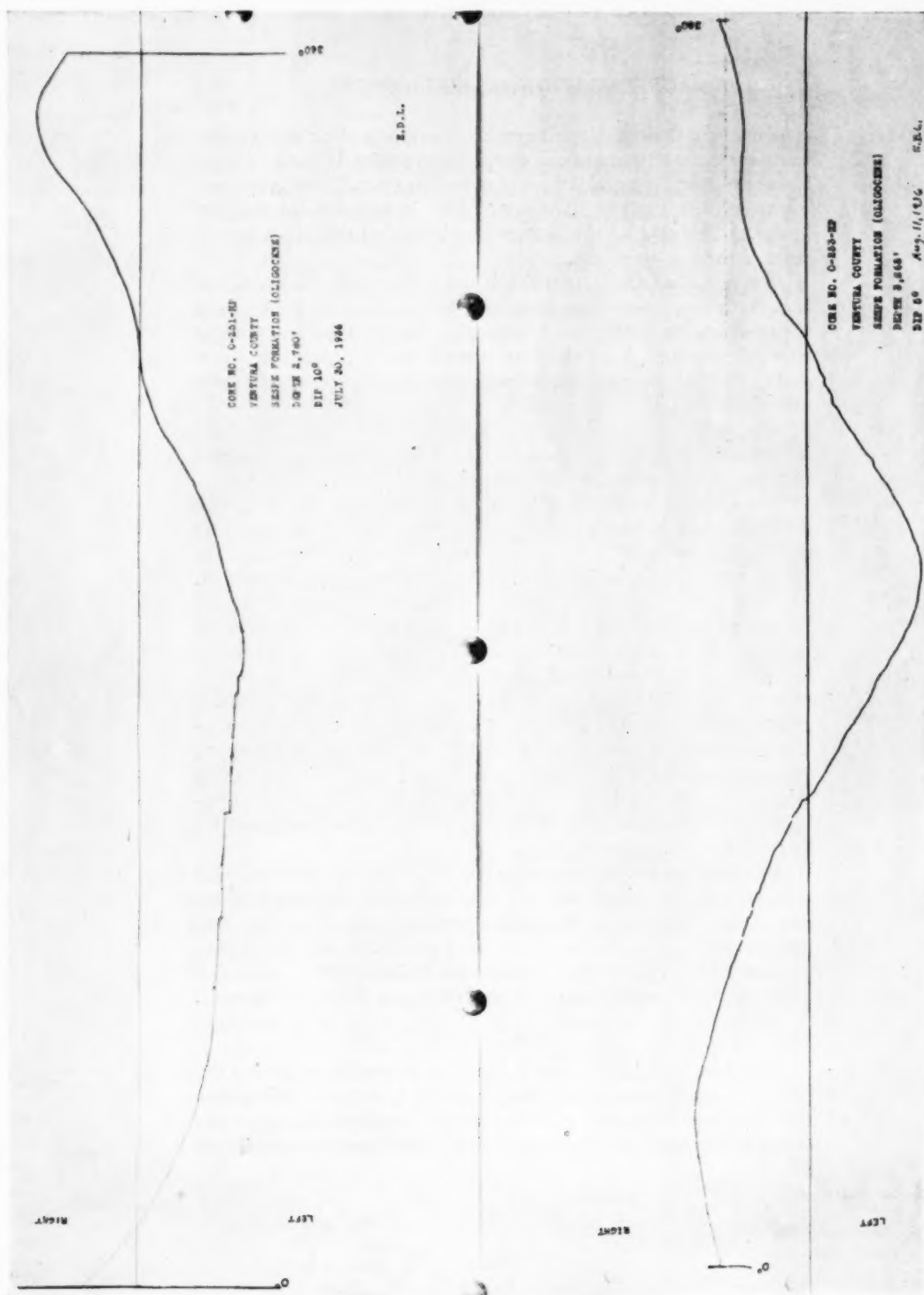


FIG. 20.—Type curves on homogeneous cores with self-recording 1936 machine.

FIG. 20.—Type curves on homogeneous cores with self-recording 1936 machine.

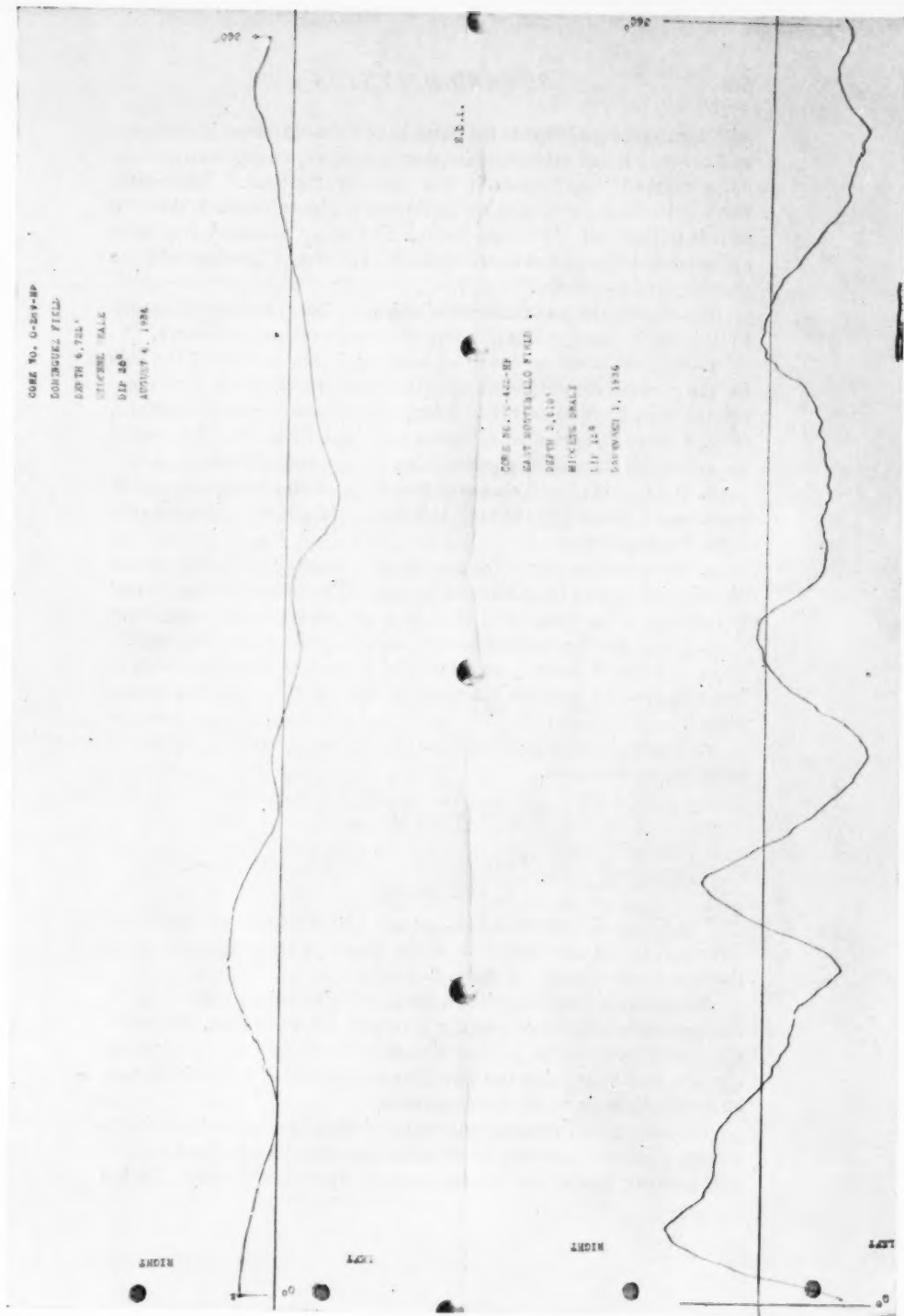


FIG. 21.—Type curves on homogeneous cores with self-recording 1936 machine showing irregularities caused by crystals of varying sizes.

with incorrect tops because the cores have been examined in the trays and turned around after examination or the trays have been erroneously marked "top" when it was actually "bottom." The safest method is for the geologist or petroleum engineer to mark the core as it is pushed out of the core barrel. The other necessary requisites are good bedding planes and a sufficient amount of core material for shaping into a cylinder.

The outstanding advantages of orienting cores in the laboratory by this method are evident. A few of them are listed as follows.

1. No time is lost on a drilling well in going in and out of the hole for the purpose of running an orienting core barrel, where sometimes several cores have to be taken before a satisfactory core is obtained.
2. Cores to be oriented by this method can be hand-picked out of the trays and chosen for good bedding planes and suitable sizes.
3. If a well is several thousand feet deep and it is desired to orient cores from higher up in the hole, this can be done easily provided such cores are available.
4. By orienting cores frequently in a drilling well, changes in direction of dip can be quickly ascertained. These changes may be due to faulting or the crossing of the axis of an asymmetrical anticline.
5. Cores can be shipped to the laboratory from any distance.
6. A series of cores, 3 to 5 covering a vertical depth of about 50 feet will give an average direction of dip, on which reliance can be placed.
7. The method is rapid and inexpensive compared to the use of orienting core barrels.

PART II

DEVIATION CORRECTOR

INTRODUCTION

The effect of a crooked hole, or one whipstocked in a calculated direction, in the determination of the direction and degree of dip of the strata was recognized early.

Whenever a hole is deviated, then the orientation worked out by the magnetic core orienter is the apparent dip and strike. To obtain the true dip and strike, a correction must be applied to the apparent dip and strike by using the direction and degree of drift of the hole at the depth from which the core came.

For example, if the magnetic core orienter has determined an apparent 5° dip due north, and the direction and degree of drift of the hole is given as 10° due north, then the apparent 5° north dip be-

comes a true dip of 5° due south. From this, it can be readily seen that a correction for drift of hole is very important, especially in low-angle dips.

ACKNOWLEDGMENTS

The writer is indebted to R. G. Reese for his suggestions in the design of the deviation corrector, and to E. L. Ickes of the Western Gulf Oil Company for his mathematical computations which were used to check the instrument.

DESCRIPTION OF DEVIATION CORRECTOR

The apparatus is shown in Figure 22 and is described briefly as follows.

It consists of a horizontal base on which is pasted a large horizontal cardboard protractor which, in addition to a deviation direction azimuth scale, is provided with a scale of concentric lines indicating the angular degree of deviation of the pointer from the vertical. In working the device, the true north-south line through the horizontal base is set in that direction by means of a Brunton compass. A vertical frame extends upward with a horizontal arm which supports a vertical rod passing through a ball, which acts as pivot. The pointer at the lower end vertically coincides with the center of the horizontal protractor. The upper end of the vertical rod supports a square plate representing the bedding plane of the stratum to be determined. To the underside of this plate is attached a vertical protractor on which is set the apparent degree of dip. The whole is rotatably mounted on the vertical shaft so that the apparent direction of dip of the stratum to be determined can be set off. The horizontal pointer located just above the center ball is set east and west when the shaft is vertically above the center of the cardboard protractor. After the vertical rod has been swung to the required deviation position, the whole must be rotated in its deviation position until this horizontal pointer is again east and west.

The procedure for making the correction from apparent direction of dip to true direction of dip is very simple and requires less than 5 minutes. For example, an apparent direction of dip was worked out on one well, at a depth of 7,036 feet as being 40° , S. 54° W. This is set off on the upper plate representing the stratum or bedding plane, while the rod is vertical and the horizontal pointer is east and west. The deviation of hole is 16° , S. 66° E. The pointer at the bottom of the vertical shaft is set off on the concentric ring marked 16° and also on the bearing of S. 66° E. In this position the vertical shaft is rotated

until the horizontal pointer is east and west. With a Brunton compass, a strike line is marked on the tilted upper plate. The direction of the strike line is read with the Brunton compass and the true dip

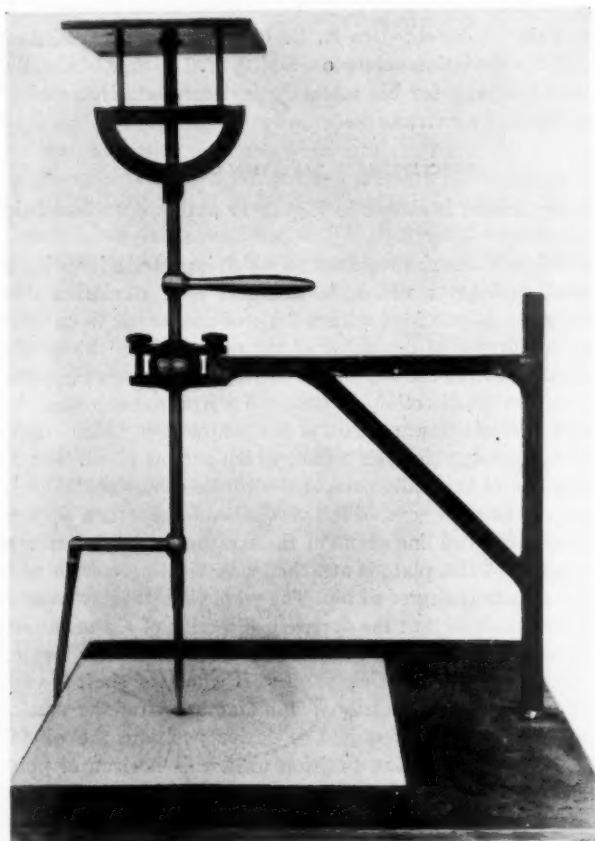


FIG. 22.—Deviation corrector, vertical position.

is taken off at right angles to the strike line. In this particular example the true degree and direction of dip were determined as 50° , S. 70° W. as compared to the apparent dip of 40° , S. 54° W. Figure 23 shows the position of the instrument tilted 6° for deviation and the bedding plane inclined 25° .

MATHEMATICAL METHOD OF CORRECTING FOR DEVIATION

Direction cosines of hole and of axis of core, all measured from horizontal and vertical axes.—

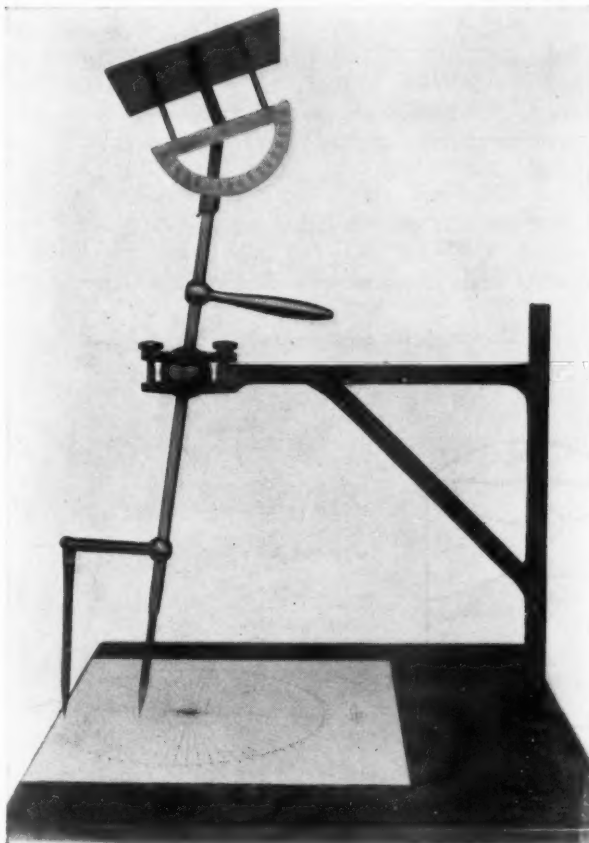


FIG. 23.—Deviation corrector, inclined 6° , bedding plane 25° .

$$l_1 = \cos P \sin d$$

$$m_1 = \sin P \sin d$$

$$n_1 = -\cos d$$

P = direction in which hole points from north-south meridian

d = acid bottle or degree off vertical of hole (always +)

Direction cosines of normal to strike plane through axis of core.—

$$l_3 = -\frac{K}{A} \text{ (always +) } K = +\sqrt{m_1^2 + n_1^2} = +\sqrt{1 - l_1^2}$$

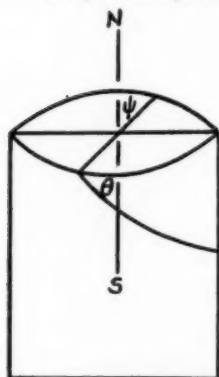
$$l_3 = +\sqrt{\frac{1 - K^2 \cos^2 \psi}{1 + l_1^2}} \cdot A = +\sqrt{\frac{K(1 + l_1^2)}{1 - K^2 \cos^2 \psi}} = +\sqrt{\frac{1 + l_1^2}{\frac{1}{K^2} - \cos^2 \psi}}$$

$$m_3 = \frac{l_1 m_1 l_3 + n_1 K \cos \psi}{K^2}$$

$$n_3 = \frac{n_1 l_1 l_3 + m_1 K \cos \psi}{K^2}$$

ψ = strike angle measured on end face of core (from north-south line)

$\cos \psi$ is always + for all strikes used by geologists.



$$l_1^2 + m_1^2 + n_1^2$$

$$= l_3^2 + m_3^2 + n_3^2$$

$$= l_2^2 + m_2^2 + n_2^2 = 1$$

Direction cosines of normal to bedding plane.—

$$l_2 = l_1 \cos \theta + l_3 \sin \theta$$

$$m_2 = m_1 \cos \theta + m_3 \sin \theta$$

$$n_2 = n_1 \cos \theta + n_3 \sin \theta$$

θ = Core dip angle measured from perpendicular end of core specimen. θ is + or - depending on the direction of dip referred to the core axis

True strike of bedding plane is ϕ where

$$\tan \phi = -\frac{l_2}{m_2}$$

Full dip of bedding plane referred to horizontal plane is where

$$\cos \Delta = n_2$$

Example.—The apparent direction of dip obtained by the core orienter from a certain well at a depth of 7,036 feet is 40° , S. 54° W. The hole deviates 16° , S. 66° E.

Substituting in the previously developed formula, the true direction and degree of dip is calculated to be $49^\circ 42'$, S. $67^\circ 30'$ W. This method is not practical because it takes about an hour to work even with a calculating machine. The formula was developed to prove the mechanical deviation corrector and shows that it checks the computations to 1° – 3° .

Table V compares the accuracy of the two methods available for correcting for deviation of hole.

TABLE V

Apparent Dip Magnetic Core Orienter	Deviation of Drill Hole	True Degree and Direction of Dip	
		Formula	Deviation Corrector
40° , S. 54° W. Time:	16° , S. 66° E.	$49^\circ 42'$, S. $67^\circ 30'$ W. 1 hour	50° , S. 70° W. 3–5 min.

IMPORTANCE OF GEOLOGICAL DATA IN ACIDIZING OF WELLS¹

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ABSTRACT

The most important geological factors which affect acidizing are the chemical composition of the producing formations, porosity and permeability, stratigraphy, structure, and physical characteristics of the producing formation.

The effect of each of these factors on the results of chemical well treating are discussed and means of avoiding certain difficulties which may arise because of impurities in the formation are mentioned.

Acidizing is defined as the process of introducing inhibited hydrochloric acid into predominantly limestone formations to enlarge the pores by removing obstacles and constrictions from them and extending them into new drainage areas, thus lowering the resistance offered to the flow of oil and gas through the oil-bearing formation.

Any study concerned with the practical and economic phases of this process will naturally lead to a consideration of some of the more important factors that govern the response a well makes to an acid treatment. It is the purpose of this paper to point out the various geological factors with which acidizing is concerned and to show how these factors may affect the process.

At first glance there does not appear to be any close relation between geology and acidizing. Consideration of the various geological factors involved will show, however, that there is not only an important relationship, but that the success of the treatment depends to a great extent on such important items as the physical character and composition of the bed or beds subject to treatment and to a lesser extent on the relation of the beds to each other.

CHARACTER OF LIMESTONE RESERVOIRS

Although limestone may be deposited by organic, chemical, or mechanical agents, in general it is a sedimentary material deposited beneath the sea at a rather slow rate. The material was subjected to certain influencing factors such as current and wave action resulting in a bed that is laterally rather homogeneous.

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² Research engineer, Dowell Incorporated.

³ Research geologist, Dowell Incorporated.

The porosity and permeability of limestones vary greatly, however, due to the previously-mentioned causes plus the rate of deposition, amount of impurities, climatic and seasonal changes, compaction, solution, and precipitation. For example, in the Bowlegs pool at Seminole, Oklahoma, there is an irregular barren streak through the center of the pool in which the initial production of the best wells was less than 100 barrels. Wells on both sides came in with initial productions averaging more than 300 barrels daily. Another example is an area in the McCamey field of Ector County, Texas, where the wells produced 500-2,500 barrels daily, while on both sides of this strip the wells had daily initials of 200 barrels or less. Other examples⁴ are known to exist wherever oil is found in limestone reservoirs.

While it is not necessary to go into the causes for these differences it is well to bear in mind that they do exist and that they have an important influence on the accumulation of oil and gas. This conspicuous peculiarity of limestone oil reservoirs is also a significant factor to be considered when wells become subjects for acid treatments.

Continuity of porosity.—The porosity of a limestone oil reservoir may be divided into two classes: continuous porosity, suited to the accumulation and commercial production of oil; and discontinuous porosity, unfavorable to the accumulation and production of oil. It should be noted, however, that oil may be contained in cavities which are not connected.

Examples of continuous porosity are so numerous as not to require separate mention. An example of discontinuous porosity is found in the upper Monroe limestone in some parts of the Vernon pool, Isabella County, Michigan. Fitzgerald and Thomas⁵ observe that secondary deposition of fluorite may have been responsible for the porosity becoming discontinuous and this offers a possible explanation for the erratic behavior of the wells in this pool. The precipitation of the fluorite continued with the infiltration of oil with the result that many of the crystals are characterized by hydrocarbon inclusions (Fig. 1). It is not unlikely that secondary deposits of other minerals

⁴ C. E. Dobbin and C. E. Erdmann, "Oil and Gas in Montana," *Problems of Petroleum Geology* (Amer. Assoc. Petrol. Geol., 1934), p. 706.

G. E. Eddy, "Geology of the Crystal Oil Field, Montcalm County, Michigan," *Michigan Dept. of Conservation Progress Rept. 1* (July, 1936), p. 7.

A. N. Murray, "Limestone Oil Reservoirs of the United States and Ontario, Canada," *Econ. Geol.*, Vol. 25, No. 5 (August, 1930), pp. 466-67.

J. M. Muir, *Geology of the Tampico Embayment Region, Mexico* (Amer. Assoc. Petrol. Geol., 1936), pp. 167-68.

⁵ P. E. Fitzgerald and W. A. Thomas, "The Occurrence of Fluorite in Monroe Formation of the Mount Pleasant Oil Pool," *Michigan Acad. Sci.*, Vol. 16 (1931), p. 416.

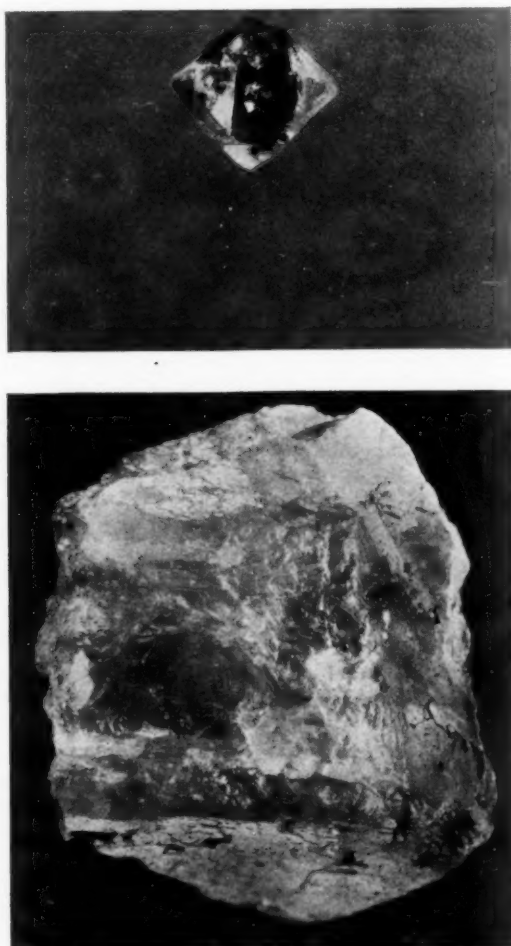


FIG. 1.—Fluorite crystal showing inclusions of hydrocarbons.
Magnification 2X.

such as calcite,⁶ celestite, and barite⁷ may account for continuous porosity becoming discontinuous or even completely destroyed.

⁶ A. N. Murray, *op. cit.*, p. 453.

⁷ A. C. Lane, personal communication.

The fact that porosity may be continuous or discontinuous has an important bearing on the estimation of results to be obtained from chemical well treatments. It also partly determines the materials to be used and the technique to be employed in the treatment. Special acids have been developed to accelerate reaction and to allow penetration of very fine openings. Special treatments have also been developed for acidizing "tight" wells, or wells producing from formations with low permeability.

Original porosity.—The term "original porosity" or "primary porosity" is used to designate the pores in limestones which exist due to the processes by which, and the conditions under which, they are deposited. This class of porosity is found in all limestones and according to Murray⁸ varies directly with the uniformity of the grain size and inversely with the intensity of compaction and induration. This type of porosity tends to be discontinuous due to the filling of finer material and cement in between the grains or fragments. It is concluded therefore that limestones with only original or primary porosity would not form important oil reservoirs.

Secondary porosity.—Probably the most important evidence, although circumstantial, indicating that the original pore spaces of limestone have been enlarged and connected by solution of material by meteoric waters during periods of emergence is that nearly every known limestone oil reservoir⁹ in the world lies at or near an erosional unconformity. In practically all limestone reservoirs the porosity has been developed by the action of chemical agencies on limestone after deposition and induration.

Murray and Love¹⁰ state that the chief agents of leaching are carbonic acid and organic acids such as formic, acetic, propionic, butyric, and oxalic. All ground waters contain more or less carbonic acid which is developed when air dissolves in water; organic acids are formed by the action of bacteria on organic material such as leaves, woods, and grasses.

These acids which are carried by ground waters over and through the exposed limestone beds filter into every crevice and pore dissolving small amounts of limestone. While it is only natural that some of these acid-bearing waters should percolate slowly downward until the water table is reached or an impervious bed is encountered,

⁸ A. N. Murray, *op. cit.*, p. 454.

⁹ W. V. Howard, "A Classification of Limestone Reservoirs," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 12 (December, 1928), p. 1155.

¹⁰ A. N. Murray and W. W. Love, "Action of Organic Acids upon Limestone," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 13, No. 11 (November, 1929), p. 1467.

lateral movement or movement parallel with the bedding planes begins as soon as the waters have penetrated the surface. The rate of movement of the waters in any direction and at any depth from their entrance will be governed largely by the distribution of the primary porosity, by the comparative solubility of the different parts of the beds, and by the attitude of the beds. It is to be expected that the largest amount of continuous porosity should develop more or less parallel with the bedding planes where, by virtue of the mode of origin of the beds, resistance to migration is the least.

Proof that a large majority of the oil-bearing pores do extend horizontally rather than vertically is found in hundreds of wells that have been drilled to within a few feet of the depth at which it was almost certain that water would be encountered, yet little or no bottom water entered the wells for long periods of time. If it were true that both vertical and horizontal porosity were present in approximately equal amounts it would be necessary to drill only to the top of many oil-bearing formations in order to recover a large percentage of the oil.

It is not meant to infer that vertical porosity never exists in an oil-producing formation. As a matter of fact there are clear-cut cases of where it does exist and in a few areas it appears to be of as great magnitude or greater than the horizontal porosity.

An examination of cores reveals that vertical porosity in many places is due to fracturing or minor faulting rather than to solution channels in the limestone. This appears to be true in Rice County, Kansas; Winkler County, Texas; Terre Haute, Indiana;¹¹ Luling, Texas; and Tampico, Tamaulipas.¹²

In the Rodessa field of Caddo Parish, Louisiana, and Cass County, Texas, a different type of vertical porosity is encountered. In a part of this field the producing formation, which is oölitic limestone, is overlain by a very porous, loosely cemented coquina bed. Gas actually passes downward through this bed into the oölitic limestone causing excessive gas-oil ratios.

Apparent vertical porosity may be found in some places in formations in which the solution channels or cavities are practically small caverns. This type of porosity is generally developed in more or less massive, soluble beds that are devoid of important or closely spaced bedding planes. Such porosity exists in the Yates pool of Pecos County, Texas, the Crystal pool, Montcalm County, Michigan, and parts of the Lorraine pool, Ellsworth County, Kansas.

¹¹ W. V. Howard, *op. cit.*, p. 1160.

¹² J. M. Muir, *op. cit.*, p. 165.

INFLUENCE OF STRUCTURE ON ACIDIZING

In general it may be said that the structure which localized the accumulation of oil in any pool is of little importance in determining whether the wells in that pool may be successfully acidized. However, in specific instances the attitude of the beds to be acidized is an important geological feature to be considered in order to avoid serious difficulties when chemical treatments are employed.

The greatest amount of porosity, as indicated previously, occurs parallel with the bedding planes and, therefore, any solution which enters the rock will travel more readily parallel with those planes than it will at an angle to them. In some limestone fields the beds which contain the oil dip at relatively high angles and when these beds are

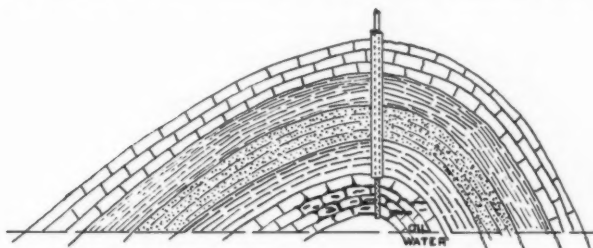


FIG. 2.—Diagram showing oil-water relationship in steeply dipping beds.

acidized the tendency is for the acid to move downward parallel with the dip.

While this is unimportant in areas where there is no danger of encountering water immediately below the oil, it is of great importance when it is known that water lies close below the oil (Fig. 2). In areas where this latter condition is known to exist its importance is generally appreciated and auxiliary chemicals are employed to minimize the downward movement of the acid. Experience has taught that acid is no respecter of fluids contained in the pores of a limestone bed and that it will enlarge pores occupied by water as readily as it will those filled with oil and gas.

STRATIGRAPHIC INFLUENCE

While the effect of stratigraphy on the results of acidizing may appear to be remote in many areas where oil is produced from a single individual bed, its effect is immediately recognized when fields such as the Fitts of Pontotoc County, and the Edmond and Britton of Oklahoma County, Oklahoma, are considered. In the Fitts pool pro-

duction is obtained from the Hunton, Viola, Bromide, McLish, and "Wilcox" formations (Fig. 3). As many as 4 of these formations are exposed in many individual wells and all are productive. The importance of having accurate geological knowledge before attempting to acidize one of these wells is very evident, especially when it is realized that each of several of the formations is sufficiently porous and permeable to absorb the acid as rapidly as it can be introduced into the well.

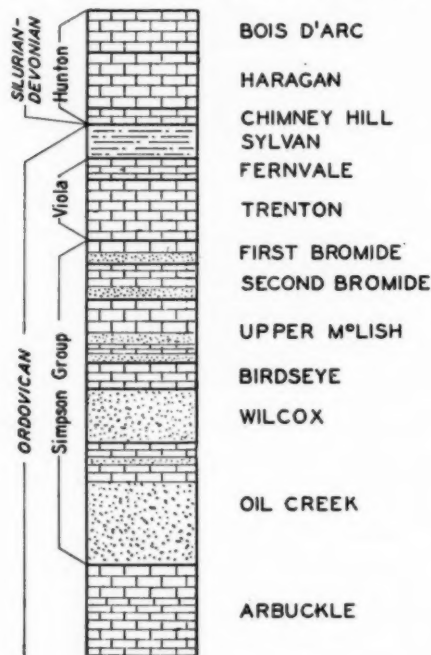


FIG. 3.—Stratigraphic section in Fitts pool area showing producing formations. After Hyatt, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 7 (July, 1936), p. 954.

In the Edmond and Britton pools conditions are essentially the same as in the Fitts pool except that fewer producing formations are present. In both pools the Simpson limestone is underlain by the "Wilcox" sand, the sand in general being much more permeable than the limestone. This general arrangement of beds is also found in northwest Wyoming in the Byron-Garland, Oregon Basin area where the Tensleep sandstone is overlain by the Embar limestone.

Wherever conditions such as have just been described are encountered the acidizing technique must be changed rather radically from that ordinarily employed when only one pay zone is present, for the following reasons. Since a single one of the formations exposed in the hole may be porous enough to absorb the acid as rapidly as it can be introduced into the well through the tubing, it is impossible to acidize thoroughly several formations at the same time. In areas, such as those cited, which have a very porous sand pay underlying the limestone which it is desired to acidize, a large proportion of the treating solution will enter the sandstone unless adequate steps are taken to prevent it. Even where the bottom sand is less porous and appreciable quantities of acid do reach the upper limestone formations, the result is that the acid penetrates only the most porous of these and does not readily enter the others.

In such places it is common practice before acidizing to plug off the sand with a temporary jelly plug¹³ which becomes semi-solid within a few minutes after introduction into the well. Then, after the lowermost limestone has been acidized an additional jelly plug is introduced to cover this formation and the next above it is acidized. The process is repeated until all of the formations have been treated. Within a day or two the jelly plug again liquefies and flows from the well with the oil.

Another stratigraphic feature which in some places influences the results of an acid treatment is the presence of shale beds immediately overlying a limestone producing formation. If the shale is one which slakes and caves when water or a water solution comes into contact with it, care must be exercised in preventing the treating solution from contacting it.

LITHOLOGIC INFLUENCES

The chemical composition of a formation is the most basic of all the geologic factors which influence the results of acidizing. If the minerals composing the formations are not soluble in hydrochloric acid it is futile to even consider the influence of structure, stratigraphy, or porosity.

Generally, formations which may be successfully treated with chemicals are composed largely of calcium carbonate or calcium-magnesium carbonate. Other constituents of the formation which sometimes exert an important effect on acidizing results, and which must be considered before acidizing, are insoluble sand grains, shale, clay, iron and aluminum oxides, gypsum, and anhydrite.

¹³ P. E. Fitzgerald and F. R. Holland, "Use of Gel Compounds Aids in Acidizing Wells" *Oil and Gas Jour.*, Vol. 35, No. 38 (February 4, 1937), p. 46.

While both limestone and dolomite, or dolomitic limestone, are soluble in hydrochloric acid, the rates at which they dissolve differ considerably (Fig. 4). It is essential that the approximate composition

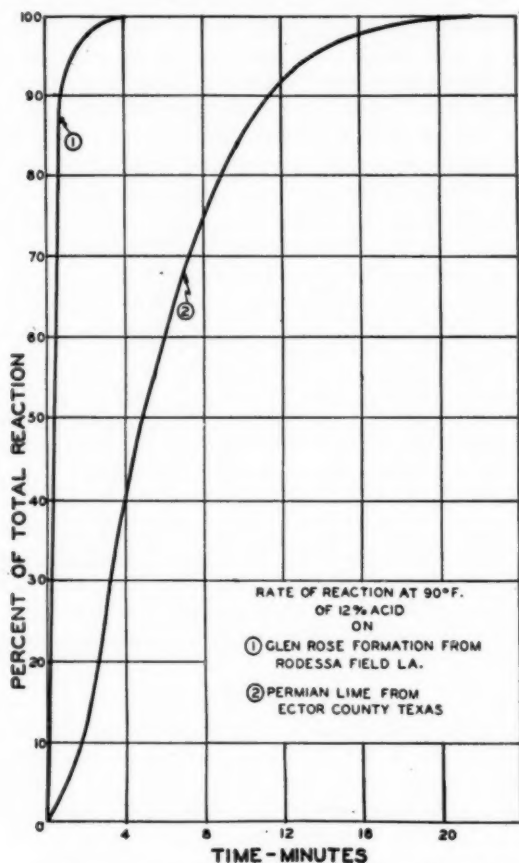


FIG. 4.—Curves showing differences in rates of reaction of same acid on two different formations.

of the formation be known to the treating engineer in order that he may intelligently acidize the formation because the speed of reaction governs the length of time the acid should remain in the formation and in many instances this shut-in period determines whether the treatment is successful.

PLUGGING IN SANDY LIMESTONES

It is known to every geologist that all limestone beds are not pure limestone. Some impurities in such beds have little or no significance as far as acidizing is concerned while others may determine almost entirely the technique to be employed in the treatment. Sandy limestone, particularly limestone which has sand grains disseminated through it, is always treacherous to acidize and on acidizing may occasionally show a decrease in production.

This decrease is due in some places to the partial plugging of the pores by sand grains or insoluble, fine materials which are freed by the reaction of the solvent with the limestone matrix. If this sandy condition is appreciated before the acidizing operation, the pore-plugging can be partly or wholly avoided by suitable change in the treating technique.

EFFECT OF CLAY OR SHALE

A petrographic examination and heavy mineral analysis of samples of the Siliceous limestone from certain oil reservoirs in western Kansas reveals that this formation contains a small, but very important percentage of a clay-like mineral which occurs as an interstitial filling between the dolomite crystals. Similar studies made by Eddy¹⁴ indicate that the residues from the Dundee formation of the Mount Pleasant oil pool do not conform to typical Dundee "purity." Some samples of the formation contain gray-to-brown shale indicating that the Dundee in this locality might have a shaly facies, having been laid down in close proximity to some land mass. In the areas where the clay is found the producing formation is relatively nonpermeable and considerable difficulty is encountered in treating the wells.

In other areas where formations with low porosity and permeability are acidized, there is ordinarily some difficulty in getting the acid "started," but it generally goes into the formation more easily as the treatment progresses and the pores are enlarged. However, in those wells in which the formation contains the clay-like insoluble material it frequently becomes impossible to complete the treatment since the acid enters the formation with more and more difficulty. This apparent "tightening up" of the formation is thought to be the result of plugging of the fine pores by these insoluble materials which become disengaged when the formation is dissolved. These materials are of low specific gravity and are carried into the pores and lodged against

¹⁴ G. E. Eddy, "A Study of the Insoluble Residues of the Lower Traverse, Bell and Upper Dundee Formations of Michigan," *Michigan Acad. Sci.*, Vol. 18 (1932), pp. 358-59.

constrictions or obstructions in the pore spaces and channels. This, of course, restricts the flow of the solvents and as more pressure is applied the clogging materials become more tightly wedged. Until this difficulty was solved it was thought impossible to treat such wells. Now a fair percentage of success can be attained as a result of improvements in the method of treatment.

IRON AND ALUMINUM PRECIPITATES

When the geologist examines a formation which is believed to be a subject for an acid treatment he should be careful to notice the presence of certain iron and aluminum compounds. These compounds are soluble in a relatively strong acid solution, but in the almost neutral spent acid solution resulting from the reaction of the acids with the limestone, they will be reprecipitated as insoluble ferric hydroxide and aluminum hydroxide. These precipitates are colloidal and their precipitation is accompanied by an increase in volume, making them fairly effective plugging agents. Ferric hydroxide will precipitate when the acid concentration reaches 0.018 per cent hydrochloric acid or less and the aluminum hydroxide when the acid concentration is 0.004 per cent or less.

Oil-producing formations generally do not contain a high percentage of either iron or aluminum oxides but analyses of cores from the Permian limestone of West Texas, the Panhandle dolomite of the Permian of West Texas, the Lansing limestone of western Kansas, and the Tyner of northeastern Oklahoma show that the ferric oxide content varies from 0.14 to 0.4 per cent. One sample of the Permian limestone from Crane County, Texas, contained 2.08 per cent and another from Howard County, Texas, contained 2.14 per cent ferric oxide.

While the percentages of iron found in the formation in these districts may appear to be unimportant it is to be remembered that their occurrence may make for the success or failure of the chemical treatment.

The most feasible way to eliminate possible difficulties of this type is to be sure to withdraw the treating solution from the formation before it is neutralized below the point at which precipitation of the products takes place.

GEOLOGICAL NOTES

MAGNETIC IRON SULPHIDE OF PLIOCENE OF VENTURA BASIN, CALIFORNIA

Magnetic iron sulphide of diagenetic origin occurs in the Pliocene sediments (Pico formation) of the Ventura basin, California. This ferrous mineral is found in the course of sieve analyses of cored sands and in washing the shale samples for *Foraminifera*. Fragments of the mineral are removed from their disaggregated matrices by means of a magnet; they are abundantly present in some zones and absent in others. These fragments are black, usually of resinous luster. The surfaces are irregular. By mineral and chemical tests the material is shown to contain iron and sulphur.

Many of the fragments show the structure of wood tissue; they are similar in appearance to wood particles seen in the sloughs along the present California coast. It is believed that the Pliocene ferrous sulphide was formed by processes like those in the modern sloughs and in bacterial environments near shore. The "black mud milieu" or sulphuretum is easily observed in the tideland sloughs; here, where the mud is blackest and the hydrogen sulphide odor strongest, are buried the largest quantities of vegetable matter particles; these are bits of wood brought by the rivers and of plants transported by the tides. In and around these particles is a complicated bacterial environment which has been enlighteningly described by Galliher.¹ He shows that the vegetable proteins give energy for one set of bacteria and that one product of the cycle is hydrotroilite, $\text{FeS}_x(\text{H}_2\text{O})_y$, an "amorphous, hydrous sulphide of iron." Dana indicates that the name "troilite" is given to the ferrous sulphide which is found in meteorites and that troilite is "considered to be the end member of the pyrrhotite series." Pyrrhotite is magnetic, being the ferrous sulphide.

The retention of wood structure in these fragments of metallic mineral in the Pliocene indicates their derivation from vegetable matter that was altered. Cartwright points out the common occurrence of carbonized vegetable matter in the Pliocene sediments; this, he believes, was furnished by kelp beds such as now exist off-shore along the coast, and by debouching rivers.² The winter rains of this region

¹ E. Wayne Galliher, "The Sulphur Cycle in Sediments," *Jour. Sed. Petrol.*, Vol. 3, No. 2 (August, 1933), pp. 51, 52.

² Lon D. Cartwright, "Sedimentation of the Pico Formation in the Ventura Quadrangle," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 3 (March, 1928), p. 258.

bring large amounts of driftwood to the rivers' mouths; much of this is waterlogged and accordingly is presumably widely distributed over the bottom, just as it is along the beaches and in the sloughs in the present rainy seasons. Undoubtedly similar conditions existed in the Ventura basin during Upper Pliocene time. The quantities of black fragments in some Pliocene horizons and their absence in other horizons point toward variations from time to time, perhaps seasonally, in the amount of woody matter which was being deposited.

The evidence of Galliher's work on the Monterey Bay deposits and of the processes going on in the sloughs show that the bacteria are using vegetable proteins for energy in the sulphur cycle and that ferrous sulphide is being precipitated. The end-product of the processes is to be seen in the iron sulphide of the Pliocene sediments. The fact that in this mineral the woody structure was retained indicates that the sulphide is a replacement.

In some places the replacement action was complete, the fragments consisting entirely of iron sulphide. In other places the replacement was partial, since bituminous matter remains in the fragments. Still other particles are entirely bituminous, totally unreplaced, simply carbonized wood. ZoBell's work shows that the greatest numbers of bacteria are in the uppermost few centimeters of marine deposits and that the numbers decrease rapidly with depth of burial. That author mentions some other factors important in the distribution of marine bacteria, for instance the availability of oxygen.³ It appears that geological factors, such as rapidity of deposition, must also have been important. It is clear that the magnetic mineral of the Pliocene was derived from the hydrotroilite mentioned by Galliher.

An interesting Pliocene core sample unusually rich in the ferrous mineral consisted, after washing, chiefly of black fragments of which about ten per cent were affected by the magnet. While the cores from above and below contained normal Pico (Upper Pliocene) groups of *Foraminifera*, the sample in question gave a narrowed faunule represented by pyrite-filled tests. The three species present in this state are tentatively referred to *Globobulimina pacifica* Cushman, *Bolivina pygmaea* H. B. Brady, and *Cassidulina corbyi* Cushman and Hughes. These species do not occur in the cores immediately above and below. It appears that the conditions which gave rise to the notably large amount of iron sulphide were in some way related to the narrowed fauna. *Bolivina pygmaea* and *Cassidulina corbyi* now appear to be con-

³ C. E. ZoBell and D. Q. Anderson, "Vertical Distribution of Bacteria in Marine Sediments," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 3 (March, 1936), pp. 258-69.

fined to the deeper parts of the San Pedro channel.⁴ That this was not due to a temporarily restricted basin is suggested by non-pyritized tests of the ubiquitous pelagic genus *Globigerina*.

Very likely the prominent pyrite seen in certain shales from the Los Angeles basin was formed in some way similar to the sulphide of the Ventura basin.

The foregoing appears to account in part for the magnetic phenomena exhibited by certain Pliocene sediments.⁵

RANDALL WRIGHT

VENTURA, CALIFORNIA
April, 1937

SALT DOMES, METEOR CRATERS, AND CRYPTOVOLCANIC STRUCTURES

Boon and Albritton¹ suggest that cryptovolcanic structures may have been caused by the impact of meteors. The suggestion is weakened by the fact that the meteor craters known to the writer, by visit or reading, do not show a central dome, an encircling syncline, or peripheral faults, not counting the crater-wall as a fault. All of these features occur on cryptovolcanic structures and, with the possible exception of peripheral faults, they occur also on salt domes. In view of the plasticity of Gulf Coast sediments, no mechanical significance need be attached to the question as to whether or not the sides of the rim-synclines are followed by peripheral faults.

Meteor Crater, Arizona, differs further from the other two types of structure, in having a strong set of radial faults across its rim, a feature absent or not well defined in salt domes and cryptovolcanic structures.

The salt-dome type of structure resembles the cryptovolcanic also in combining features assignable to central uplift with others assignable to central subsidence, possibly at a different period. The main difference between them is the greater number of faults that can be mapped on many cryptovolcanic structures, a difference due possibly to the better exposures of the latter, and to the more brittle character

⁴ M. L. Natland, "Temperature and Depth Distribution of Foraminifera in California," *Bull. Scripps Inst. Ocean.*, Tech. Series, Vol. 3, No. 10, pp. 225-30.

⁵ Quantitative relationship between "Magnetic Susceptibility and Magnetic Content of Sands and Shales," is outlined by D. M. Collingwood, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, No. 9 (September, 1930), pp. 1187-90.

¹ John D. Boon and Claude C. Albritton, "Meteor Craters and Their Possible Relationship to 'Cryptovolcanic Structures'," *Field and Laboratory* (Southern Methodist University, Dallas, Texas), Vol. 5, No. 1 (November, 1936), pp. 1-9.

of the rocks in which they occur. Both types of faulted dome require local concentration of vertical stress, but, in the writer's opinion, neither requires the violent explosive action inferred by Bucher.² Indeed, one of his supposed "cryptovolcanic structures," Upheaval Dome, in southeastern Utah, lies in a region of known salt domes, and its surface structure shows no essential difference from that of a salt dome.

Geophysical surveys might indicate whether cryptovolcanic structures have cores of relatively heavy rock (igneous), as thought by Bucher, or of relatively light rock (salt, clay-shale, or gypsum). All of these substances create diapir folds, but, so far as known to the writer, domes or anticlines pierced by cores of clay-shale lack rim synclines around them.

CHESTER W. WASHBURN

NEW YORK, NEW YORK
April 5, 1937

GEOLOGY OF TRINIDAD

E. Lehner, author of "Introduction à la géologie de Trinidad," which was published in *Annales des Combustibles Liquides* (Paris), No. 4 (July-August, 1935), pp. 693-730, calls attention to the distorted form of the folded illustration showing the north-south schematic vertical and horizontal distribution of the formations. The author states that he was absent when the manuscript was printed and he was unable to see proof. He feels, therefore, that he is not responsible for the typographical errors that appear in the article. Unfortunately the same faulty section was reproduced to illustrate H. G. Kugler's "Summary Digest of Geology of Trinidad," which was published in the *Bulletin* of the American Association of Petroleum Geologists, Vol. 20, No. 11 (November, 1936), Fig. 2, p. 1448. As the original printing in the *Annales* was not proof-read by Lehner and as the reprinting in the *Bulletin* was not a part of the manuscript submitted by Kugler, neither author should be held responsible for discrepancies in the form of the geologic section as printed.

THE EDITORS

² William H. Bucher, "Cryptovolcanic Structures in the United States," *Internat. Geol. Congr., XVI Sess., U.S.A., 1933, Rept.* (Washington, D. C.), Vol. 2 (1936), pp. 1055-84.

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library and available to members and associates.

Die Rotary-Bohrmaschinen und ihre Antriebe (Rotary Drilling Equipment and Power). By L. STEINER. Laubsch and Everth, Berlin (1936). 140 pp., 63 figs. 6×9 inches. Price: paper, \$1.25.

In this booklet the author presents the latest information regarding the construction, operation, and power needed for rotary drilling outfits. The remarkable advances made during the last 10 years in rotary equipment stand out prominently. The illustrations are particularly clear and helpful. Various kinds of power used are discussed in considerable detail. Their relative advantages and disadvantages are impartially set forth. To anyone interested in the technology of drilling procedure particularly with regard to comparative expense, this booklet will prove indispensable.

W. A. VER WIEBE

WICHITA, KANSAS
April, 1936

**Manual on Geophysical Prospecting with the Magnetometer*. By J. WALLACE JOYCE. U. S. Bureau of Mines (March, 1937). 129 pp., 53 illus. Price: \$1.50. For sale by the American Askania Corporation, Houston, Texas.

This manual which is one of a series under preparation was printed by the American Askania Corporation under a cooperative agreement with the Bureau of Mines. The purpose of the manual is to describe the instruments, the theory, field technique, and some of the underlying fundamental principles of interpretation of magnetic prospecting with the Schmidt type magnetometer.

The author first takes up the properties of magnets and magnetic fields and next the magnetic field of the earth including its variations. This is followed by a clear presentation of the theory of the vertical magnetometer and of the horizontal magnetometer covering their sensitivity and the use and function of auxiliary magnets. These two magnetometers, as instruments, are then described in detail with particular attention to their magnetic systems and the zero temperature coefficient system.

A section is devoted to factors influencing magnetometer readings. These include the effect of temperature on scale reading and on scale value, the effect of change in the position of the center of gravity of the magnetic system, and the effect of misorientation and misleveling. Another section takes up the method of making the necessary corrections. This involves a treatment of the temperature and the daily variation correction, the latitude and longitude correction, and the effect of vertical intensity on the horizontal magnetometer.

The completeness of the manual is illustrated by the chapter on operating technique, which explains how to set up and take readings and how to use an auxiliary magnet when a reading is off scale. It also includes a discussion of necessary precautions such as the proper care of the instrument in transportation, its protection from jarring, the proper manner of releasing and clamping

the magnetic system, and precautions against possible damage from dirt on the bearings and knife edge.

The author includes a section on the determination of the temperature coefficient and of the scale value using auxiliary magnets or a Helmholtz coil. Planning a magnetometer survey covers the choice of stations and the choice of traverse lines. Preparation of magnetometer data treats isodynamic contour maps, three-dimensional or "egg-crate" models, and "disturbance vectors."

The last chapter carries the title, "Interpretation of Magnetometer Data." Seven type examples of the theoretical anomaly for different dike-type magnetic bodies are presented. These show, in separate graphs for vertical and for horizontal intensity, the component arising from the south pole of the body and that from its north pole and the resultant intensity. Further actual examples of field data and their preparation and interpretation are given. One covers a survey of a large magnetic mineralized zone, another covers dikes and steeply dipping beds and a third the mapping of formation boundaries. Discussion accompanies these examples.

Seven qualifications for a competent interpreter of geophysical surveys are listed and of these the first is experience and the second is a fundamental knowledge of geology. In conclusion it is brought out by the author that in general certain fundamental rules of interpretation may be formulated, but that these are of value only in so far as their limitations are recognized and their discreet use supplemented by experience, and in view of all known geological and physical factors involved in a given problem. The manual well fulfills its purpose and is a definite contribution to geophysical literature.

DART WANTLAND

COLORADO SCHOOL OF MINES
GOLDEN, COLORADO
April 3, 1937

RECENT PUBLICATIONS

AFRICA

*"Les conditions géologiques des recherches de pétrole au Maroc" (The Geologic Conditions of Petroleum Research in Morocco), by M. J. Lacoste. *Compte-Rendu des Séances du Groupes des Géologues Pétroliers de Strasbourg*, Vol. 3, Nos. 4-6 (1935-36), pp. 23-37.

*"Carte géologique: Cameroun-Oubangui-Chari" (Geologic Map: Cameroon-Ubangi-Shari), by Georges Korableff. *La Chronique des Mines Coloniales* (Paris), Vol. 6, No. 60 (March 15, 1937), pp. 126-28; geologic map.

ARGENTINA

*"Los Insectos fósiles del Norte argentino y la edad del Horizonte Calcáreo-Dolomítico" (The Fossil Insects of North Argentina and the Age of the Calcareous-Dolomitic Horizon), by Otto Schlagintweit. *Bol. Inform. Petrol.* (Buenos Aires). Reprint of No. 145 (1936), pp. 61-69; 1 pl.

ARKANSAS

*"Concretions in the Fayetteville Shale," by Albert W. Giles and A. M. Jones. *Jour. Geol.* (Chicago), Vol. 45, No. 2 (February-March, 1937), pp. 204-13.

BRAZIL

*"Sobre a tectonica da área de São Pedro-Xarquedra" (Tectonics of São Pedro-Xarquedra), by Victor Oppenheim and Mark C. Malamphy. *Serviço de Fomento da Produção Mineral* (Rio de Janeiro) *Avulso* 7 (1936). 12 pp., 9 maps and charts. In Portuguese.

*"As ocorrências do Poço São João, em Riacho Doce, Estado de Alagoas" (Occurrences at the São João Well, Riacho Doce, State of Alagoas), by Eugenio Bourdot Dutra. *Ibid. Avulso* 5 (1936). 11 pp., 12 figs.

*"Prospecção geophysica em São Paulo" (Geophysical Prospecting in São Paulo), by Irnack Carvalho do Amaral and Henrique Capper Alves de Souza. *Ibid. Bol.* 10 (1936). 102 pp., 28 figs., 8 folded inserts, 12 plates.

*"Turfa de Marahú, Estado da Bahia" (Sapropelitic Peat in Bahia), by Nero Passos. *Ibid. Spec. Pub.* (1936). 8 pp., 1 map, 1 group of cross sections, 1 photo.

*"Quadro chrono-geologico do Brasil" (Chrono-Geological Table of Brazil), by Djalma Guimarães. *Instituto Brasileiro de Min. e Met. Spec. Pub.* 1 (1936). 7 pp., including table of formations. Reprint from *Mineração e Metallurgia* (Rio de Janeiro), No. 2 (July-August, 1936).

ECUADOR

**The Geology of South-Western Ecuador*, by George Sheppard. Thomas Murby and Company, 1 Fleet Lane, Ludgate Circus, London, E. C. 4. 269 pp., 170 illus., maps, and diagrams. For sale at Association headquarters, Box 1852, Tulsa, Oklahoma.

GENERAL

*"Study of Oil Fields May Aid in Discovery of Fresh Reserves," by W. V. Howard. *Oil and Gas Jour.* (Tulsa), Vol. 35, No. 43 (March 11, 1937), pp. 26-28; 1 map, 1 table.

*"Discovery Rates in Oil Finding," by Wallace E. Pratt. *Ibid.*, No. 45 (March 25, 1937), pp. 46, 48, 50; 3 tables. *Oil Weekly* (Houston), Vol. 85, No. 2 (March 22, 1937), pp. 16-18, 53.

**Annotated Bibliography of Economic Geology for 1936*, prepared under auspices of Society of Economic Geologists. Vol. 9, No. 1 (January, 1937). 226 pp. Published by Economic Geology Publishing Company (Lancaster, Pennsylvania).

*"Zur Chemie des Gesteinsbitumens" (On the Chemistry of Bituminous Rocks), by Guido Hradil. *Petrol. Zeit.* (Wien), Vol. 33, No. 8 (February 24, 1937), pp. 1-4.

*"L'emploi de l'avion pour les recherches géologiques et minières dans les pays neufs" (The Use of the Airplane for Geological and Mining Investigations in New Country), by F. Blondel. *La Chronique des Mines Coloniales* (Paris), Vol. 6, No. 58 (January 1, 1937), pp. 2-15; 7 figs.

"Inferences about the Origin of Oil as Indicated by the Composition of the Organic Constituents of Sediments," by Parker D. Trask. *United States Geol. Survey Prof. Paper* 186-H (February, 1937), pp. i-ii, 147-57. Price, 10 cents. May be purchased from Supt. of Documents, Govt. Printing Office, Washington, D. C.

*"Future of Petroleum Exploration in the United States," by E. DeGolyer. *Oil Weekly* (Houston), Vol. 85, No. 3 (March 29, 1937), pp. 16-19; *Oil and Gas Jour.* (Tulsa), Vol. 35, No. 46 (April 1, 1937), pp. 57, 58.

*"Flow of Mixtures of Oil and Water through Sand," by F. B. Plummer, J. C. Hunter, Jr., and E. H. Timmerman. *Oil Weekly* (Houston), Vol. 85, No. 4 (April 5, 1937), pp. 65, 66, 68, 70; 3 figs. *Oil and Gas Jour.* (Tulsa), Vol. 35, No. 47 (April 8, 1937), pp. 42, 45; 3 figs.

**Geodetic Letter* (U. S. Coast and Geodetic Survey, Division of Geodesy, Washington, D. C.), Vol. 4, No. 1 (January, 1937). 93 mim. pp. This issue is devoted to 14 articles on state plane coördinates.

On the Mechanism of the Geological Undulation Phenomena in General of Folding in Particular and Their Application of the Problem of the "Roots of Mountains" Theory, by S. W. Tromp. A. W. Sijthoff's Uitgeversmaatschappij N. V. (Leiden, Holland, 1937). 184 pp., 89 figs. Paper.

World Petroleum Directory, 1937 edition. 1,200+pp. Information on corporate structure, financial organization, officers, statistics covering United States, Canada, and 125 other countries. Contains names of 20,000 individuals and their connections in various branches in the oil business. World Petroleum, 56 West 45th Street, New York City. Price, \$10.00.

*"Bull. Geol. Soc. America (New York). Vol. 47 (March 1, 1937), pp. 1981-2020; 1 fig. This is a discussion of papers in Volume 47.

*"Position, Extent, and Structural Makeup of Appalachia," by W. T. Thom, Jr. *Bull. Geol. Soc. America* (New York), Vol. 48, No. 3 (March 1, 1937), pp. 315-22; 1 fig., 1 pl.

*"Homotaxial Principle in Geological Classification," by Charles Keyes. *Pan-American Geol.* (Des Moines, Iowa), Vol. 67, No. 3 (April, 1937), pp. 215-30; 1 fig.

"Magnetic Declination in the United States, 1935," prepared by U. S. Coast and Geodetic Survey. Serial No. 592 (March, 1937). About 50 pp., 1 fig., 1 chart. May be purchased from Supt. of Documents, Govt. Printing Office, Washington, D. C. Price, 20 cents.

Petroleum Production, by Wilbur F. Cloud. University of Oklahoma Press (Norman, 1937). 613 pp., 280 illus., 75 tables. Cloth. Price, \$5.00. Among the many subjects treated are legal phases of production, oil-field development, equipment, repressuring, prime movers, operating methods, storage, preparing crude oil for market, production of natural gas, sand conditions, reservoir energies, prevention of waste, methods of increasing recovery, and economy of production practices.

GEOPHYSICS

*"New Method of Seismic Survey Affords More Information," by Lester C. Uren. *Oil and Gas Jour.* (Tulsa), Vol. 35, No. 43 (March 11, 1937), pp. 52, 54; 6 illus.

*"Talking Motion Pictures in Geophysics," by Carl Dreher. *Petroleum World* (Los Angeles), Vol. 34, No. 3 (March, 1937), pp. 47-59; 8 figs., 4 illus. Discusses how sound recording has been adapted to geophysical prospecting; "clean-up method" reduces or eliminates unwanted vibrations obtained in shooting, thus opening up greater areas for successful exploration.

*"Reflection Seismic Instruments and Their Efficiency," by C. A. Heiland. *Petroleum Engineer* (Dallas), Vol. 8, No. 6 (March, 1937), pp. 91, 93, 96, 98; 2 figs.

*"The Interpretation of Geophysical Data," by L. W. Blau. *Oil Weekly* (Houston), Vol. 85, No. 3 (March 29, 1937), pp. 23-26, 28.

**Manual on Geophysical Prospecting with the Magnetometer*, by J. Wallace Joyce. *U. S. Bur. Mines* (1937). Printed by the American Askania Corporation under a cooperative agreement with the U. S. Bureau of Mines. 129 pp., 53 figs. 6×9 inches. Paper. For sale by American Askania Corporation, Houston, Texas. Price, \$1.50.

GULF COAST

*"Some Causes of Blow-Outs during Drilling and Means of Prevention, with Special Reference to Gulf Coast Region," by Charles B. Carpenter. *U. S. Bur. Mines Information Cir.* 6938 (March, 1937), 27 mim. pp., 3 tables.

INDIA

*"Drilling Mud: Its Manufacture and Testing," by P. Evans and A. Reid. *Trans. Min. and Geol. Inst. of India* (Calcutta), Vol. 32 (December, 1936). 263, xxx pp., 98 figs., many tables. Price: members and associates, Rs. 7/8; non-members, Rs. 12/ excluding postage and foreign tariff. U. S. import duty, \$0.60.

KANSAS

*"Depth of Deposition of the Big Blue (Late Paleozoic) Sediments in Kansas," by Maxim K. Elias. *Bull. Geol. Soc. America* (New York), Vol. 48, No. 3 (March 1, 1937), pp. 403-32; 4 figs., 1 pl.

KENTUCKY

Natural Gas in Eastern Kentucky, by W. R. Jillson. 237 pp. Illus. Standard Printing Company, Louisville, Kentucky.

LOUISIANA

State of Louisiana base map (1936). Scale, 1 inch=about 16 miles. Size, 21×22 inches. Price, 5 cents. May be purchased from Supt. of Documents, Govt. Printing Office, Washington, D. C. This map shows county names and boundaries, township lines, the location and names of all cities and towns and most of the smaller settlements, also railroads, lakes, rivers and many of the smaller streams and coastal swamps, bays, and sounds. Printed in black only and does not show contours or elevations.

NEW MEXICO

"Geology and Fuel Resources of the Southern Part of the San Juan Basin, New Mexico: Part 3, The La Ventana-Chacra Mesa Coal Field," by C. H. Dane. *United States Geol. Survey Bull.* 860-C (February, 1937), pp. i-v, 81-166, Pls. 39-55, Fig. 3. Price, 40 cents. May be purchased from Supt. of Documents, Govt. Printing Office, Washington, D. C.

NEW YORK-PENNSYLVANIA

*"Hamilton Correlations," by Bradford Willard. *Amer. Jour. Sci.* (New Haven, Connecticut), Ser. 5, Vol. 33, No. 196 (April, 1937), pp. 264-78; 1 fig., 2 tables.

NORTH AMERICA

*"Development and Present Status of Geology in North America," by W. C. Mendenhall. *Bull. Geol. Soc. America* (New York), Vol. 48, No. 3 (March 1, 1937), pp. 349-64.

OKLAHOMA

*"History of the Canadian River of Oklahoma as Indicated by Gerty Sand," by T. A. Hendricks. *Bull. Geol. Soc. America* (New York), Vol. 48, No. 3 (March 1, 1937), pp. 365-72; 3 figs.

RUSSIA

*"Neue Funde von Silurischen Bryozoen" (New Find of Silurian Bryozoa), by W. Nekhoroshev. *Trans. Central Geol. and Prospecting Inst.* (Moscow), Fascicle 61. 40 pp., 2 pls.

*"A Study of the Thickness of Deposits as a Method of Geotectonic Analysis and Its Application to the Study of Upper Jurassic and Lower Cretaceous Deposits of the Caucasus," by V. V. Belousov. *Prob. Soviet Geol.* (Moscow), Vol. 7, No. 2 (1937), pp. 121-41; 7 figs. In Russian. Summary in English.

*"Carboniferous and Permian of the Southern Urals," by M. K. Elias. *Amer. Jour. Sci.* (New Haven, Connecticut), Ser. 5, Vol. 33, No. 196 (April, 1937), pp. 279-95; 1 fig.

TEXAS

*"A Trip to Anahuac," by Charles Leyendecker. *Oil Weekly* (Houston), Vol. 85, No. 2 (March 22, 1937), pp. 37-50; 3 illus., 1 map, 3 tables; No. 3 (March 29, 1937), pp. 30-40; 8 figs., 2 tables; No. 5 (April 12, 1937), pp. 23-28; 3 illus., 1 table.

VENEZUELA

**Boletín de geología y minería* (Caracas), Vol. 1, No. 1 (January, 1937). 90 pp., illus., maps. Contains, among others in Spanish, an article by R. Rutsch on "Tertiary Gastropods in Falcon and Lara, Venezuela," and an article by C. Wiedenmayer on "Carboniferous of Coro, Miranda District, Falcon." Also contains a list of papers delivered before the first Geological Congress of Venezuela.

WASHINGTON

*"The Geology of Washington—Part I, General Features of Washington Geology," by Harold E. Culver. *Washington Dept. Conserv. and Dev., Div. Geol. Bull.* 32 (1936). 70 pp. Accompanying preliminary geologic map of state of Washington, 32 × 48½ inches; scale, 1 inch = 8 miles; colored.

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Ashly Stanford Holston, Los Angeles, Calif.
Homer J. Steiny, Joseph Jensen, James C. Kimble
Henry Glenn Walter, Hobbs, N. Mex.
Edgar W. Kimball, Frank B. Conselman, Ralph A. Koenig

FOR ASSOCIATE MEMBERSHIP

Beverly B. Bradish, Wilson, Okla.
E. B. Branson, W. A. Tarr, O. A. Seager
William Allen Bramlette, Austin, Tex.
Hal P. Bybee, H. Gordon Damon, E. H. Sellards
Jenaro González, Mexico, D. F.
William G. Kane, F. H. Lahee, Ezequiel Ordoñez
Phillip Dobbs Helmig, Jr., Artesia, N. Mex.
H. S. Cave, J. B. Headley, Delmar R. Guinn
Willis George Meyer, Houston, Tex.
James W. Kisling, Jr., John S. Cruse, Jr., Kenneth Dale Owen
William Albert Newton, Urbana, Ill.
M. M. Leighton, F. W. DeWolf, A. H. Bell
Russell Spurgeon Poor, Birmingham, Ala.
M. M. Leighton, Harold R. Wanless, A. N. Murray
Reese Herrick Tucker, Bartlesville, Okla.
Robert L. Kidd, William F. Absher, A. K. Wilhelm

FOR TRANSFER TO ACTIVE MEMBERSHIP

Julian Devreau Barksdale, Seattle, Wash.
L. C. Snider, E. P. Hindes, V. R. Garfias
E. F. Boehms, Abilene, Tex.
K. B. Nowels, Joseph E. Morero, Hal P. Bybee
George Hunter Coates, San Antonio, Tex.
Chas. H. Row, Thornton Davis, Ed. W. Owen
Mason G. Walters, Port Allegany, Pa.
Charles R. Fettke, Jack Gaddess, Frank E. Eckert

(Continued on page 681)

TWENTY-SECOND ANNUAL MEETING

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
BILTMORE HOTEL, LOS ANGELES, CALIFORNIA
MARCH 17-19, 1937

The twenty-second annual meeting of the Association was held under the auspices of its active, efficient, and large Pacific Section. The general chairman, Frank A. Morgan, and his committee assistants merit the thanks of all attendants for their superior technical and social program. Routine official matters were attended to as usual by business manager Hull, assisted by Misses Whalen and Cummings of the Tulsa office. The total registration was 1,062: honorary members 3, members 378, associates 33, non-member men 424, and 227 non-member women.

Delegates to the convention came from many parts. As was expected, however, the larger number came from the Pacific Coast, the Gulf Coast, the Mid-Continent, and the Rocky Mountains. It was gratifying, though, to see so many from the north-central states, the east coast, and Canada. Both before and after the convention many of the delegates toured California extensively for the purpose of enjoying its many singular attractions. Excellent roads, the ocean, beautiful homes, and the semitropical climate appealed to the visitors.

General registration and executive committee meetings began March 15. On the 16th, official single and joint committees deliberated their problems, concluding with the usual informal dinner and discussion sponsored by the research committee. In the afternoon a field excursion examined the stratigraphy and structure of the Santa Monica Mountains and north part of the Los Angeles Basin, returning to headquarters via the Inglewood oil field. Just before the research committee dinner the Wildcat committee, California Oil and Gas Association, received and entertained the visiting guests.

On March 17 the sessions opened in the ball room of the Biltmore Hotel with an address of welcome by A. L. Weil, president of the California Oil and Gas Association, and a response by past-president A. I. Levorsen. General technical sessions and separate technical sessions by the Society of Exploration Geophysicists followed all day. At noon visiting ladies were entertained with a luncheon and fashion show at Bullock's Wilshire. In the afternoon paleontologists and stratigraphers inspected the various oil fields and formations of the San Pedro Hills, with especial emphasis on micropaleontology. Late in the afternoon announcements, nomination of officers, and appointments of committees were considered in the general session. The stag smoker held in the evening at the Rendezvous, Biltmore Hotel, was an eye opener in more ways than one. That calculus could be mixed entertainingly with almost all forms of modern entertainment appealing to stags proves the foresight and originality of the smoker committee. It was excellent and will be hard to excel.

On March 18 general technical sessions continued simultaneously with those of the Society of Exploration Geophysicists and the Society of Economic Paleontologists and Mineralogists, the last named organization holding its annual business meeting in the late afternoon. College and fraternity luncheons were held at the hotel. Shortly after noon the ladies visited the Henry E. Huntington Library and Art Gallery and then attended a reception at the beautiful home of Dr. and Mrs. R. D. Reed in Pasadena. The field excursion

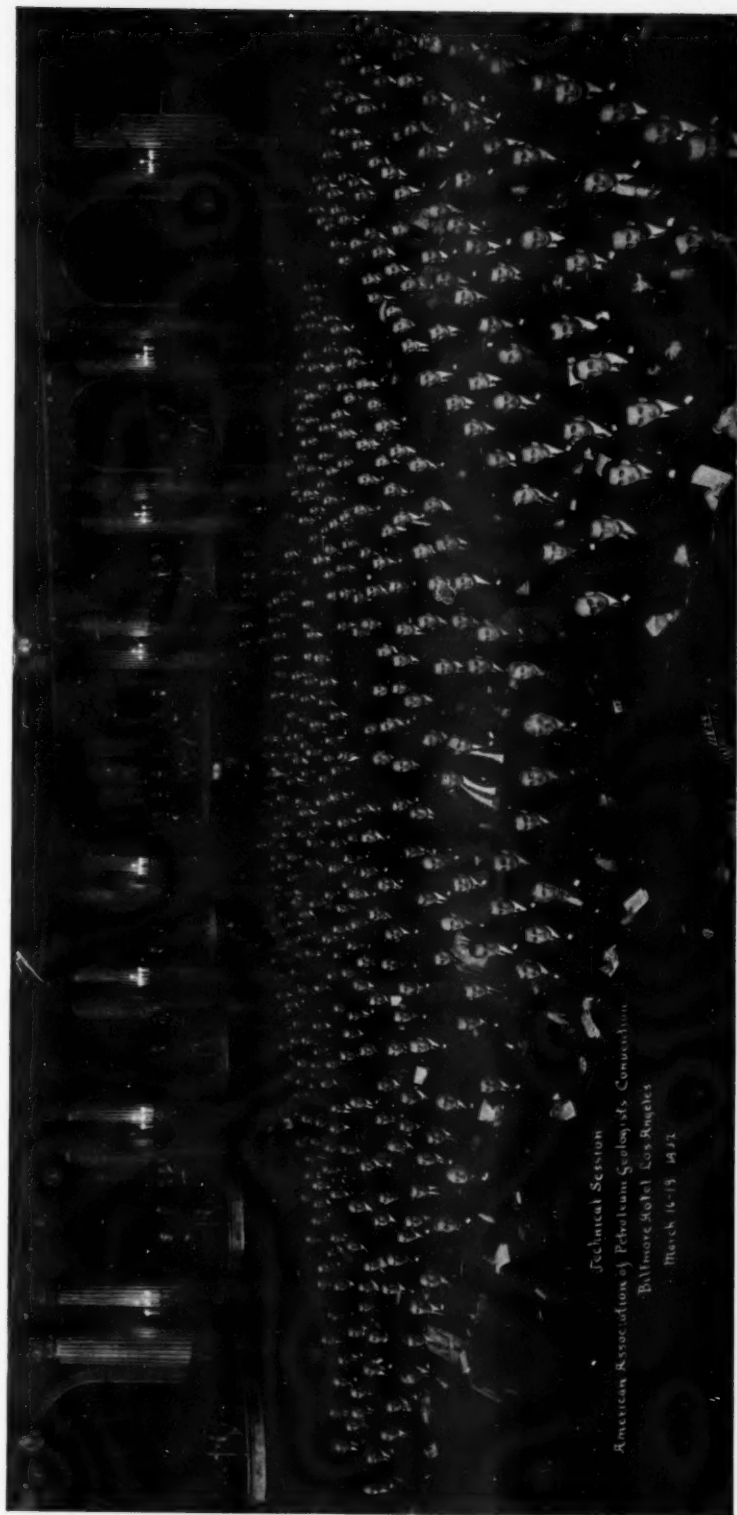


Courtesy of *Petroleum World*

Members of executive committees at twenty-second annual meeting, Los Angeles, March 19, 1937. Seated, left to right: Ira H. Cram, incoming secretary-treasurer; H. B. Fuqua, incoming president; R. D. Reed, outgoing president. Standing, left to right: A. I. Levorsen, outgoing past-president; C. E. Dobbins, outgoing vice-president; Chas. H. Row, outgoing secretary-treasurer; C. L. Moody, incoming vice-president. Those absent are L. C. Snider, outgoing editor and W. A. Ver Wiebe, incoming editor.



Annual dinner dance, twenty-second annual meeting, Biltmore Hotel Bowl, Los Angeles, March 18.



Technical session, twenty-second annual meeting, Biltmore Hotel, Los Angeles, March 17.



Courtesy of Petroleum World

PRESIDENT R. D. REED AND THE PACIFIC SECTION CONVENTION COMMITTEE OF THE TWENTY-SECOND ANNUAL MEETING

Top row, left to right: R. W. Sherman, general committee; Angus McLeod, chairman golf committee; Robert B. Moran, general committee; Vernon L. King, general committee; W. S. W. Kew, chairman field trips; A. A. Curtice, chairman finance; H. J. Steiny, chairman transportation; Richard G. Reese, chairman entertainment; Roy M. Barnes, chairman publicity and exhibits.

Bottom row, left to right: Earl B. Noble, chairman hotels; C. R. McCollom, chairman reception; Ralph D. Reed, president of the Association; Mrs. W. S. W. Kew, in charge of ladies entertainment; Harry R. Johnson, president Pacific Section; Frank A. Morgan, general chairman; Harold W. Hoots, chairman technical program.

during the afternoon to part of the Los Angeles Basin emphasized the technical features of the Dominguez, Wilmington, and Signal Hill oil fields. The dinner dance in the world-famous Biltmore Bowl, with the exclusive use of the Bowl and the French Bar adjoining, was a very elaborate and enjoyable affair. Music for dancing was furnished by a famous orchestra, and a special floor show featured talented entertainers.

March 19 started with the twenty-second annual business meeting of the Association, which was followed by a joint meeting of the 1936 and 1937 executive committees, and the general technical sessions. The ladies toured the moving picture studios in Hollywood while some of the men competed at golf. In the golf tournament Dean Stacy of Oklahoma City, Elford Beck of Tulsa, A. E. Wallace (guest) and A. A. Curtice of Los Angeles made the best scores. Stacy and Wallace had low gross for the 18 holes. Curtice was low for the first nine and Beck low for the second nine. In the late afternoon a field excursion to the San Joaquin Valley left the Biltmore Hotel en route to Bakersfield. The old Los Angeles City oil field was of interest, also the many and varied stratigraphic and structural features clearly observed along the entire route. The day concluded for this group with an informal dinner at the El Tejon Hotel, Bakersfield.

On March 20 the San Joaquin Valley excursion enjoyed a barbecue in Alcalde Canyon under ideal weather conditions, and visited the following oil fields: Lost Hills, Kettleman Hills, Belridge, McKittrick, Elk Hills, Buena Vista Hills, and Ten Sections. The geological section at the Coalinga field was examined, and especial interest taken in the many different types of oil-producing structures present in the Valley. The night was spent at the El Tejon Hotel, Bakersfield.

The last trip of the convention was the Ventura County excursion on March 21. Visitors saw some 43,000 feet of crumpled Cenozoic strata from one spot, the picturesque South Mountain oil field, the perfectly closed Ventura Avenue anticline, the Elwood anticline, and smaller domal fields, large overthrust faults, and other structural and physiographic features resulting from the Pleistocene Coast Range revolution.

The exhibits were comprehensive, and of especial interest to petroleum geologists, geophysicists, and paleontologists. Geophysical instruments, devices for surveying wells, electrical logging, locating water, perforating casing, and orienting cores, as well as oil field and air maps, specialized core bits, and geological and paleontological instruments were well displayed and described.

The technical programs included papers on the geology, oil possibilities, and recent developments in the United States and foreign countries, on geophysics, air mapping, orientation of cores, the future of oil exploration, the interrelationship of geology and geophysics, and a symposium on the Cretaceous and Tertiary stratigraphy and paleontology of California. The papers were interesting, well balanced, well attended and heard perfectly throughout the large ballroom. In addition to including the order of business, abstracts of papers, names of exhibits and exhibitors and the oil companies who contributed generously to the general convention fund, the printed program listed a large number of oases in town, described their attractions and stated that the only cure for all of them was a 480-mile ride to Reno, Nevada—taxi fare, \$125.

The convention was stimulating proof of the energy and ability of the Pacific Section, of the high regard that section holds for the parent association, and of the esteem held for the retiring president, Dr. Reed, of California.

CARROLL E. DOBBIN

NEW OFFICERS

The officers for the new year, unanimously elected at the Los Angeles meeting, are: president, H. B. Fuqua, Gulf Oil Corporation, Fort Worth, Texas; vice-president, C. L. Moody, Ohio Oil Company, Shreveport, Louisiana; secretary-treasurer, Ira H. Cram, Pure Oil Company, Tulsa, Oklahoma; and W. A. Ver Wiebe, University of Wichita, Wichita, Kansas.

The Division of Paleontology and Mineralogy elected the following: president, Stanley G. Wissler, Union Oil Company, Los Angeles, California; vice-president, F. W. Rolshausen, Humble Oil and Refining Company, Houston, Texas; secretary-treasurer, Henry V. Howe, Louisiana State University, Baton Rouge, Louisiana; editor, Raymond C. Moore (re-elected), University of Kansas, Lawrence, Kansas.

The Division of Geophysics elected the following: president, J. C. Karcher, Geophysical Service, Inc., Dallas, Texas; vice-president, F. M. Kannenstine, Independent Exploration Company, Houston, Texas; secretary-treasurer, M. E. Stiles, Independent Exploration Company, Houston, Texas; editor, M. M. Slotnick, Humble Oil and Refining Company, Houston, Texas.

CONVENTION REGISTRATION

The total registration at the twenty-second annual meeting was 1,062, the largest at any Association meeting west of the Mid-Continent. This attendance is classified as follows: 3 honorary members, 378 members, 33 associates, 424 non-member men, and 227 non-member women. Of the 21 states represented, the 10 highest totals are California (619), Texas (219), Oklahoma (86), Colorado (30), New York (16), Kansas (14), District of Columbia (10), Louisiana (10), and Wyoming (10). Nineteen persons registered from Argentina, Canada, France, Germany, Holland, Mexico, Philippine Islands, Sweden, and Venezuela.

GOLF TOURNAMENT

The annual golf tournament was held on Friday afternoon, March 19, at the Midwick Country Club, Alhambra, one of the oldest and finest clubs in southern California. Thirty-nine players were entered, 12 of whom were guests and 27, members. The J. Wallace Bostick cup was won by A. E. Wallace (guest), manager for the Western Gulf Oil Company, Los Angeles, whose low gross was 87. He was also awarded a prize by the committee. All prizes given by the Pacific Section were sterling silver plates, remembrances appreciated both by the winners and by their families. The winning score among the members was a low gross of 85, made by Elfred Beck of Tulsa and by Dean M. Stacy of Oklahoma City. The decision was given to Stacy by rolling dice. The winners and scores are tabulated.

A. E. Wallace, guest, low gross for tournament.....	87
Dean M. Stacy, member, low gross for tournament.....	85
Elfred Beck, member, low gross for tournament.....	85
A. A. Curtice, member, Los Angeles, low gross, first 9 holes.....	41
Elfred Beck, member, low gross, second 9 holes.....	44

Blind bogey prizes were won by the following.

Guy E. Miller, member, Long Beach, California
Roscoe E. Shutt, member, Tulsa, Oklahoma
Mark Woolery, guest, Los Angeles
Jess L. Bullard, guest, San Antonio, Texas

EXECUTIVE COMMITTEE

The executive committee of the Association during the year that ended with the twenty-second annual meeting, March, 1937, were: R. D. Reed, chairman; Chas. H. Row, secretary; A. I. Levorsen, C. E. Dobbin, and L. C. Snider.

PACIFIC SECTION

The Pacific Section of the Association was host to those attending the meeting. The officers of the Section are Harry R. Johnson, president, and James C. Kimble, secretary-treasurer.

CONVENTION COMMITTEE

General.—Frank A. Morgan, chairman; Frank R. Clark, E. F. Davis, G. C. Gester, W. B. Heroy, Vernon L. King, Robert B. Moran, C. R. McCollom, R. S. McFarland, R. W. Sherman.

Technical Program.—H. W. Hoots, chairman; A. A. Baker, Monroe Cheney, Ira H. Cram, C. E. Dobbin, M. G. Edwards, John F. Kinkel, Max L. Krueger, A. I. Levorsen, E. Russell Lloyd, C. L. Moody, Frank Rieber, Carroll Wagner, Paul Weaver, G. H. Westby, S. G. Wissler.

Finance.—A. A. Curtice, chairman; L. A. Cranson, R. E. Collom, L. C. Decius, Walter A. English, Dana Hogan, R. P. McLaughlin, J. R. Pemberton, Harry P. Stolz.

Entertainment.—Richard G. Reese, chairman; H. K. Armstrong, W. H. Geis, A. I. Gregerson, Stanley Herold, H. R. Johnson, Richard Kerr, W. D. Kleinpell, E. D. Lynton, C. R. McCollom, G. B. Moody, Frank Rieber, Glen Ruby.

Reception.—C. R. McCollom, chairman; E. F. Davis, J. E. Elliott, S. H. Gester, H. R. Johnson, R. P. McLaughlin, D. B. Myers, Frank Rieber, Glen Ruby, Carroll Wagner, C. P. Watson.

Publicity and Exhibits.—Roy M. Barnes, chairman; Glen Bowes, Grant W. Corby, Dick Crandall, D. Dana, Wilbur Rankin, E. H. Vallat.

Hotels.—Earl B. Noble, chairman; Raymond Greene, Fred Menken, E. G. Robinson, Lowell Saunders, Jack Sickler, Louis N. Waterfall.

Registration.—J. E. Elliott, chairman; James C. Kimble, John S. McKenna, Jack Sickler.

Field Trips.—W. S. W. Kew, chairman; W. F. Barbat, E. J. Bartosh, J. P. Buwalda, Chester Cassel, J. E. Eaton, E. C. Edwards, W. A. English, Sam Grinsfelder, H. D. Hobson, R. M. Kleinpell, Art R. May, Robt. B. Moran, E. K. Soper, Frank R. Stockton, H. P. Stolz, A. J. Tiejie, S. G. Wissler, A. O. Woodford.

Transportation.—H. J. Steiny, chairman; Denny M. Bernt, Willard Classen, J. R. Dorrance, R. N. Ferguson, J. M. Hamill, Wayne Loel.

Golf.—Angus McLeod, chairman; Ward Blodget, J. E. Elliott, F. W. Hertel, C. R. McCollom, F. C. Merritt.

LADIES' ENTERTAINMENT

General.—Mrs. William S. W. Kew, *chairman*

Registration.—Mrs. Walter A. English, *chairman*; Mesdames Edmund J. Bartosh, A. Arthur Curtice, Harry Godde, Paul L. Henderson, Harry R. Johnson, Edward D. Lynton, Angus McLeod, Frank A. Morgan, Chester Stock, Carroll M. Wagner, James T. Wood, Jr.

Transportation.—Mrs. Sam Grinsfelder, *chairman*; Mesdames H. K. Armstrong, Roy M. Barnes, Glenn H. Bowes, John P. Buwalda, Roy E. Collom, Eric K. Craig, E. F. Davis, Elmer De Maris, John F. Dodge, Herschel L. Driver, Beno Gutenberg, Walter Heathman, Stanley C. Herold, Frank S. Hudson, Donald D. Hughes, James C. Kimble, Vernon L. King, Edward D. Lynton, Downs McCloskey, C. R. McCollom, Earl B. Noble, Graydon Oliver, Howard C. Pyle, Wilbur D. Rankin, Richard G. Reese, Frank Rieber, Ernest G. Robinson, Glen M. Ruby, Ronald Swayze, Carolyn Templeton, Dwight H. Thornburg, L. R. Van Burgh, Martin Van Couvering, Francis E. Vaughan, Louis N. Waterfall, Cornelius G. Willis, and Miss Gretchen Bremermann.

Luncheon.—Mrs. Carroll M. Wagner, *chairman*; Mesdames Edmund J. Bartosh, Lewis A. Bond, James C. Kimble, Floyd C. Merritt, Frank A. Morgan.

Reception.—Mrs. Ralph D. Reed, *hostess*; assisting—Mesdames Lewis A. Bond, Chester Cassel, James R. Dorrance, M. G. Edwards, Hoyt S. Gale, Albert I. Gregerson, Harold W. Hoots, William D. Kleinpell, Max L. Krueger, Lowell W. Saunders, Chester Stock, James T. Wood, Jr.

Movie tour.—Mrs. Harry R. Johnson, *chairman*; Mesdames Frank S. Hudson, Desaix B. Myers, Frank Rieber.

SCHEDULE OF EVENTS

All meetings were in the Biltmore Hotel.

MONDAY, MARCH 15

- 2:00 P.M. Registration
7:00 P.M. Executive committee, R. D. Reed, *chairman*

TUESDAY, MARCH 16

- 9:00 A.M. Registration
9:00 A.M. Committee on applications of geology, Frank Rinker Clark, *chairman*
9:00 A.M. Committee on geologic names and correlations, Ira H. Cram, *chairman*
10:00 A.M. Executive committee and finance committee, joint meeting
10:00 A.M. Society of Petroleum Geophysicists, executive and business committees
11:00 A.M. Research committee, Donald C. Barton, *chairman*
1:00 P.M. Field trip, Los Angeles Basin
2:00 P.M. General business committee, Thornton Davis, *chairman*
5:30 P.M. Reception for visiting geologists and ladies. Guests of the Wildcat committee, California Oil and Gas Association
6:30 P.M. Informal dinner for geologists and ladies sponsored by research committee, followed by round-table discussion of research problems

WEDNESDAY, MARCH 17

- 9:00 A.M. Registration. Galeria
9:00 A.M. Society of Petroleum Geophysicists, business meeting
9:00 A.M. Opening general session. Address of welcome and response. Ball Room
9:30 A.M. General technical session. Ball Room
10:30 A.M. Technical session, Society of Petroleum Geophysicists
12:00 M. Ladies' entertainment. Luncheon and fashion show, Bullock's Wilshire

- 12:15 P.M. Geophysicists' luncheon. Biltmore Bowl
- 1:00 P.M. Field trip, Los Angeles Basin, for paleontologists and stratigraphers
- 1:45 P.M. General technical session. Ball Room
- 2:30 P.M. Technical session, Society of Petroleum Geophysicists
- 4:45 P.M. Announcements, nomination of officers, appointment of committees—general session. Ball Room
- 8:30 P.M. Stag smoker. Rendezvous

THURSDAY, MARCH 18

- 9:00 A.M. General technical session. Ball Room
- 9:00 A.M. Technical session, Society of Petroleum Geophysicists
- 9:00 A.M. Symposium on California stratigraphy, Society of Economic Paleontologists and Mineralogists. Music Room
- 12:15 P.M. College and fraternity luncheons
- 1:00 P.M. Ladies' entertainment. Trip to Henry E. Huntington Library and Art Gallery, followed by reception at 4:00 P.M. at home of Mrs. Ralph D. Reed
- 1:00 P.M. Field trip, Los Angeles Basin
- 1:45 P.M. General technical session. Ball Room
- 1:45 P.M. Technical session, Society of Economic Paleontologists and Mineralogists. Music Room
- 2:00 P.M. Technical session, Society of Petroleum Geophysicists
- 3:30 P.M. Annual business meeting, Society of Economic Paleontologists and Mineralogists. Music Room
- 8:00 P.M. Dinner dance. Biltmore Bowl

FRIDAY, MARCH 19

- 9:00 A.M. Twenty-second annual business meeting. Ball Room
- 10:00 A.M. Executive committees, joint meeting 1936 and 1937 committees
- 10:00 A.M. General technical session. Ball Room
- 12:30 P.M. Ladies' entertainment. Moving-picture studio tour
- 1:00 P.M. Golf. Automobiles leave for Midwick Country Club
- 1:30 P.M. General technical session. Ball Room
- 3:30 P.M. Field trip to Bakersfield and San Joaquin Valley
- 8:00 P.M. Field trip dinner, El Tejon Hotel. Bakersfield

SATURDAY, MARCH 20

- 8:00 A.M. Field-trip party leaves El Tejon Hotel, Bakersfield, for Kettleman Hills

SUNDAY, MARCH 21

- 8:00 A.M. Field-trip party leaves El Tejon Hotel, Bakersfield, for return via Castaic Junction and Ventura County fields

TECHNICAL PROGRAM

I. GENERAL ASSOCIATION PAPERS FOR ORAL DELIVERY

1. RALPH D. REED, Presidential address. Southern California as a Structural Type
2. DREXLER DANA, Historical Development of California Oil Fields
3. WALLACE E. PRATT, Discovery Rates in Oil Findings
4. E. DEGOLYER, The Future of Exploration for Petroleum
5. JAMES M. KIRBY, The Geology of the Sacramento Valley
6. ALEX CLARK, Miocene Correlations across the Southern San Joaquin Valley
7. FRANK RIEBER, Motion Picture Presentation of Reflected Wave Pattern from Various Geological Structures
8. L. W. BLAU, The Interpretation of Geophysical Data
9. JOHN L. RICH, Application of the Principle of Differential Settling to the Tracing of Lenticular Sand Bodies
10. JOSEPH NEELY, The Stratigraphy and Petroleum Aspects of the Sundance Formation and Related Jurassic Rocks in Wyoming
11. ROSS L. HEATON, Stratigraphy Versus Structure in the Rocky Mountain Region
12. WARREN O. THOMPSON and HARRY W. OBORNE, Paleozoic Stratigraphy and Oil Prospects of Eastern Colorado
13. JOHN G. BARTRAM, The Upper Cretaceous of the Rocky Mountain Area
14. JOSEPH S. IRWIN, Oil and Gas Possibilities of Western Canada

15. CHARLES E. WEAVER, Geology and Its Relation to the Possible Occurrence of Petroleum in Oregon and Washington
16. N. WOOD BASS, The Verden Sandstone of Oklahoma
17. E. O. MARKHAM and L. C. LAMAR, The South Burbank Pool, Oklahoma
18. E. G. THOMPSON, Fault System of Northeast Texas with Emphasis upon the Talco Structure as a Type
19. HERSCHEL H. COOPER, Occurrence and Accumulation of Oil in the Laredo District of Texas
20. E. RUSSELL LLOYD, Interpretation of Permian Stratigraphy of West Texas and New Mexico
21. MAX BORNHAUSER, Geology of the Tepetate Field, Acadia Parish, Louisiana

SYMPOSIUM ON RECENT DEVELOPMENTS

22. MARVIN LEE and GEORGE BAUGHMAN, Kansas and Nebraska
23. A. E. BRAINERD and CHAS. S. LAVINGTON, Rocky Mountain District
24. FREDERIC A. BUSH, Oklahoma
25. W. B. HEROV, Foreign Countries
26. BASIL B. ZAVOICO, Russian Oil Fields
27. M. G. EDWARDS, California
28. BERTIE R. HAIGH, West Texas and Southeastern New Mexico
29. HARRY H. NOWLAN, Southwest Texas
30. A. W. WEEKS and JOHN E. GALLEY, North and West-Central Texas and the Panhandle
31. O. L. BRACE, Gulf Coast
32. WALLACE RALSTON, Northeast Texas
33. DWIGHT H. BINGHAM, Arkansas and North Louisiana
34. J. BRIAN EBY and MICHEL T. HALBOUTY, The Spindletop Oil Field, Jefferson County, Texas
35. S. GRINSFELDER and W. S. EGGLESTON, The Geology of the Dominguez Oil Field, California
36. J. MARVIN WELLER and ALFRED H. BELL, The Illinois Basin
37. DONALD C. BARTON, Variation of Oil in the Gulf Coast
38. E. D. LYNTON, Laboratory Orientation of Well Cores by Their Magnetic Polarity
39. FRANCIS SHEPARD, Salt Domes off the Gulf Coast
40. B. W. BLANPIED and ROY T. HAZZARD, The Age and Correlation of the Chickasawhay and Bucatunna Members of the Catahoula, Wayne County, Mississippi
41. B. W. BLANPIED, The Age and Correlation of the Salt Mountain Limestone, Clarke County, Alabama
42. W. L. COZZENS, The Latest Developments in Aerial Photographic Mapping

II. GENERAL ASSOCIATION PAPERS FOR PRESENTATION BY TITLE

43. BRUCE L. CLARK, Folding of the California Coast Range Type Illustrated by a Series of Experiments
44. P. E. FITZGERALD and W. WRAY LOVE, The Importance of Geological Data in the Acidizing of Wells
45. E. A. KOESTER, Studies of Lower Paleozoic Formations in Central Kansas
46. O. L. BRACE, Interrelationship of Geology and Geophysics
47. S. GRINSFELDER and W. S. EGGLESTON, The Geology of the Dominguez Oil Field, California
48. ARTHUR S. HUEY, The Geology of the Tesla Quadrangle, Near Tracy, California
49. FRANK M. ANDERSON, The Knoxville Series in the California Mesozoic
50. KENNETH DALE OWEN, The Placedo Field of Victoria County, Texas, in Its Relationship to Gulf Coast Stratigraphy
51. E. S. SHAW, Oil Possibilities of Southern Apache County, Arizona
52. BRUCE H. HARLTON, Stratigraphy of the Bendian of the Oklahoma Salient of the Ouachita Mountains

III. PALEONTOLOGY AND MINERALOGY

SYMPOSIUM ON CALIFORNIA CRETACEOUS AND TERTIARY
STRATIGRAPHY AND PALEONTOLOGY

1. PAUL P. GOUDKOFF, The Cretaceous of the Northern San Joaquin Valley
2. FRANK B. TOLMAN, Review of the California Eocene
- 3-8. HUBERT G. SCHENCK, E. R. ATWILL, B. L. CLARK, L. C. FORREST, R. M. KLEINPELL and CHESTER STOCK, A Review of the California Oligocene

9. ROBERT M. KLEINFELL, The Miocene of Central California
10. WILBUR D. RANKIN, The Miocene of Southern California
11. HERSCHEL L. DRIVER, Correlation of Oil Fields within Los Angeles Basin, California
12. W. D. HOLMAN, The Stratigraphic Relations of Pliocene Surface Sections of the Los Angeles District
13. WILLIAM F. BARBAT, The Pliocene and Pleistocene Formations of San Joaquin Valley
14. BRADFORD C. ADAMS, The Pliocene of the Ventura Basin
15. U. S. GRANT, Some Observations on the Pleistocene of the Los Angeles Region
16. MANLEY L. NATLAND, The Distribution of Recent and Later Tertiary Foraminifera in Southern California
17. MERLE C. ISRAELSKY, Gulf Coast Markers in the Eocene of Marysville Buttes, California
18. W. P. WOODRING, Paleographic Implications of the Larger Fossils from the Repetto Formation of the Los Angeles Basin
19. CHARLES R. CANFIELD, The Subsurface Stratigraphy and Micropaleontology of the Santa Maria Valley, California
20. DONALD W. GRAVELL and MARCUS A. HANNA, A New Horizon, *Lepidocyclus texana* Gravel and Hanna, n.sp.ms. in the *Heterostegina* Zone, Upper Oligocene of Texas and Louisiana
21. STANLEY G. WISSLER, Foraminiferal Zones of the Dominguez Oil Fields, Los Angeles County, California. (By title.)
22. H. L. DURGAN, Species of the Genus *Cytheropteron* from the Weno Formation (Middle Washita) of Southern Oklahoma and Northern Texas. (By title.)

IV. GEOPHYSICS

1. BENO GUTENBERG, Geophysics as a Science
2. A. B. BRYAN, Discussion of the Gravity Meter
3. MORTON MOTT-SMITH, Adverse Effects Associated with Variably Compounded Seismic Records
4. M. H. GILMORE, Earthquake Investigations
5. J. J. JAKOSKY and C. H. WILSON, Electrical Prospecting for Oil Structures
6. J. A. SHARPE, Magnitude and Character of Elastic Waves Produced by Explosion Pressures
7. HAROLD WASHBURN, Transient Characteristics of Seismograph Apparatus
8. LYNN G. HOWELL, Atmospheric Potential Gradient Measurements
9. S. A. SCHERBATSKOY and J. NEUFELD, Fundamental Relations in Seismometry
10. HENRY SALVATORI, The Mapping of Faults by the Reflection Method
11. D. G. C. HARE, A New Source of Damped Wave Trains Suitable for Testing of Geophysical Instruments
12. ALEXANDER DEUSSEN and HUBERT GUYOD, Use of Temperature Measurements in Drill Holes for Cementation Control and Correlation
13. E. E. McDERMOTT, Discussion of Multiple Recording
14. G. H. WESTBY, Some Phases of Seismic Reflection Work in Antarctica
15. F. G. BOUCHER, The Development of the Pendulum for Prospecting
16. CURTIS H. JOHNSON, Use of the Sonograph in Mapping Faults

MINUTES, TWENTY-SECOND ANNUAL BUSINESS MEETING
 BILTMORE HOTEL, LOS ANGELES, CALIFORNIA
 MARCH 17-19, 1937

RALPH D. REED, *presiding*

The meeting was called to order at 5:00 P.M., March 17, 1937, by Ralph D. Reed, president, Chas. H. Row serving as secretary.

1. *Nominations of officers.*—The president called for nominations of officers of the Association for the ensuing year. The following nominations were made.

For president: H. B. FUQUA, nominated by Ed. W. Owen
For vice-president: C. L. MOODY, nominated by O. L. Brace
For secretary-treasurer: IRA H. CRAM, nominated by Frank R. Clark
For editor: W. A. VER WIEBE, nominated by Everett A. Wyman

There being only one nominee for each office, motion was made, seconded, and carried that the secretary be authorized to cast a unanimous ballot for each nominee.

2. *Resolutions committee.*—John G. Bartram, chairman, Roy M. Barnes and Jos. M. Dawson were appointed by the president as a committee on resolutions.

The meeting was recessed at 5:20 P.M. until 9:00 A.M., March 19, 1937.

The recessed meeting was called to order at 9:45 A.M., March 19, 1937, by Ralph D. Reed, president.

3. *Reading of minutes.*—It was moved, seconded, and carried that the reading of the minutes of the annual meeting held at Tulsa, Oklahoma, March 19-21, 1936, be dispensed with, inasmuch as they had been published in the *Bulletin*.

4. *Report of officers.*—The reports of president R. D. Reed, editor L. C. Snider and secretary-treasurer Chas. H. Row were presented (Exhibits I, II, and III).

5. *Report of general business committee.*—The report of the general business committee (Exhibit IV) was read by the chairman, Thornton Davis. It was moved, seconded, and carried that the recommendations contained therein be adopted. (The reports of the committee on geologic names and correlations, Ira H. Cram, chairman; of the research committee, Donald C. Barton, chairman; of the committee on applications of geology, Frank R. Clark, chairman; and of the representative of the Association on the National Research Council Division of Geology and Geography, F. H. Lahee, representative, appear as Exhibits, V, VI, VII, and VIII, respectively).

6. *Report of resolutions committee.*—The report of the resolutions committee (Exhibit IX) presented by John G. Bartram, chairman, was unanimously adopted.

7. *Introduction of new officers.*—The newly elected officers of the Association were introduced by retiring president Reed.

On motion by R. W. Clark a rising vote of thanks was tendered to the outgoing executive committee in appreciation of their work for the Association.

The twenty-second annual business meeting adjourned at 10:35 A.M.

RALPH D. REED, *president*

CHAS. H. ROW, *secretary*

EXHIBIT I. REPORT OF PRESIDENT (Year Ending March 19, 1937)

The problem of securing a plentiful supply of papers for the *Bulletin*, which is touched upon in Dr. Snider's report, is of so much importance that it seems worth while to emphasize some of its aspects even at the cost of repetition. Several previous executive committees have wrestled with the problem but all of them, like the present committee, could reach no conclusion except that their successors ought by all means to find a solution. We have considered hiring somebody to assist in securing papers, but there are many practical difficulties. Most of the men who could serve us effectively

are already profitably employed, and might well hesitate to change to a position that might not be permanent and would certainly be full of difficulties. If the Association were to employ a suitable man and if we as individuals were then to relax on the theory that we had no further responsibility, his task would obviously be impossible and our dearth of papers next winter would be worse than ever. If, on the other hand, all of us were to take seriously our responsibilities as members of the Association, there would be no need to employ anyone to secure papers.

Among the suggestions that have been made, that of organizing a committee to be composed of one energetic member in each district or in each center of geological endeavor, is perhaps the simplest solution and might turn out to be the best. I presume that it would be desirable to re-vamp the committee at frequent intervals, so as to replace the men who had found it impossible to function effectively, and also those who had worked sufficiently hard to deserve a rest, and a chance to write a few papers of their own.

After such a committee is organized and functioning, we may find it desirable to employ some one of our members who already has part-time employment, perhaps in a college or university; or perhaps not. At any rate, we may hope to learn from experience whether or not we need such an employee and most important of all, what we should ask him to do.

I should like to make it clear that this proposed new committee is not designed to replace our present editorial staff, which has functioned effectively for several years. What we hope to provide, by means of the new committee or otherwise, is something for the present editorial staff to edit. If the new committee should secure some papers that are not suitable for publication, the older one must be relied upon to see that they are rejected. This task should be easier for them than if they had themselves requested the papers; in any case, this duty will be theirs, as it has been hitherto, and so will the duty of assisting in the preparation of all papers and in seeing to it that they are as accurate and as excellent in all respects as they can be made.

During the past year the executive committee has been favored with the unsolicited views of just one member of the Association on the method of solving this problem. My chief reason for discussing the matter in such detail at present is my hope that other members will give it their best thought and contribute their ideas to the incoming executive committee; or if they see no ready solution, let them settle down seriously to write the paper or papers that they have long been meaning—and neglecting—to write.

Among the other subjects of major importance to the Association at present, I shall discuss only one, the problem of our relations to the Society of Exploration Geophysicists. This was the thorniest problem dropped into the lap of the present committee a year ago, and in spite of the great amount of time and thought that we have given it, the solution that we are proposing is a compromise that will not please everybody in either society. We of the executive committee are not too proud of it ourselves, but we are asking your approval of it as the best of the several unsatisfactory solutions that were open to us.

After all, the exact form of an association, or the exact legal relationship of two associations if you please, is of less importance than that the members should be able and willing to act together for the promotion of their common interests. In the past the relationship of the two organizations has been closer

than some members desired, and has therefore caused some friction; if in the future it shall come to seem too distant and too loose, we shall know by experience that such ills are remediable.

R. D. REED, *president*

EXHIBIT II. REPORT OF SECRETARY-TREASURER
(Year Ending March 19, 1937)

MEMBERSHIP

During the past year there has been an unusually heavy death toll among the Association membership. It is the sad duty of the Secretary to report the names of these losses: V. H. McNutt, L. G. Putnam, Conrad Schlumberger, Karl E. Young, Robert B. Whitehead, Wilson Keyes, Arthur S. Henley, Francois Biraud, Robert M. Whiteside, Dean E. Winchester, Otto Stutzer, John F. Kinkel, and E. D. Wappler.

The Association, during the year ending March 1, 1937, has experienced marked recovery in its membership. There has been a net increase of 162 members, distributed as follows: 254 new members and reinstatements, 7 withdrawn, 72 dropped for non-payment of dues, and 13 lost by death. It is encouraging to note that a large number of members were unusually prompt in making payments of dues in 1937. Members are urged to make their payments promptly each year so that the headquarters office may be saved the time and expense of reminding them the second time that payments are in order.

In studying the geographic distribution of Association members it is interesting to observe that all but seven of the United States are represented, that 71 per cent of the members are in five of the states, that 11 per cent are in 39 foreign countries, Venezuela being best represented with 49 members.

Details of membership are recorded in the accompanying Tables I, II, and III.

FINANCES

GENERAL

Perhaps the most important action of the fiscal year concerning the finances of the Association was the decision of the executive and finance committees to deposit the securities of the Association in a custodian account with the New York Trust Company. For a nominal fee this company handles the buying and selling of securities, collects dividends and interest, and transacts other business in connection with the ownership of stocks and bonds. Ernst E. Clad, investment counsel of New York City, was retained to observe the list of securities belonging to the Association and to advise regularly on sales and purchases to maintain the best position in the market. Of course no transactions in securities can be made without approval of the executive and finance committees. It is in order here to express thanks to former president Wm. B. Heroy for his generous assistance in completing satisfactorily these arrangements in New York City.

This year has been one of rising prices in nearly all the securities of the Association, and it has been deemed advisable to sell in only one or two cases. A number of bonds have been called in connection with refinancing programs and the funds derived from these redemptions have been reinvested in securities recommended by our counsel. It is believed that the

Association with its considerable amount of money now invested in stocks and bonds, will profit by the present arrangement for expert advice and prompt handling of its sales and purchases.

Though the audit of the books of the Association for the calendar year ending December 31, 1936, reflects a net operating loss of \$896.05, the income from investments, delinquent dues previously charged off, collections from reinstated members and sale of the office library resulted in a net income for the year of \$4,567.76. The present executive committee has expressed itself unanimously in favor of placing any yearly profits back into publications which will be of value to large groups of Association members. To this end the coöperation of the members is solicited in making available to the Association editor suitable subject material for the purpose.

REVENUES AND EXPENSES

As will be noted from examination of detailed tables accompanying this report there have been during 1936 substantial increases over 1935 in revenue from several sources. The increased membership has resulted in larger income from dues. Interest in the *Bulletin* is spreading as shown by nearly a \$500.00 increase in subscriptions over 1935. Likewise there has been very material improvement in the amount of income from advertising. Due largely to the earnest efforts of former president A. I. Levorsen and business manager Hull this item of revenue has been more than doubled the past two years. There has been an increase over last year in income from the sales of back numbers of the *Bulletin*. Sales of Special Publications have been very satisfactory though the revenue from this source was somewhat lower than in 1935. Table IV gives comparisons of income items for the past three years.

In spite of the necessary increases in several single expense items the total of General and Administrative Expenses and Publication Expenses for the year is \$287.06 lower than for 1935. In Table V of this report is a detailed account of all expenses, while Table VI shows comparisons of net income for 1934, 1935, and 1936.

INVESTMENTS

By action of the executive and finance committees immediately following the March, 1936, convention in Tulsa, after due consideration of expert financial counsel, the Treasurer was instructed to invest approximately \$10,000 of Association funds in five recommended common stocks. Purchase of this type of security was a marked deviation from common practice of the organization. At the close of the year 1936 the investment in common stocks represented only 20.9 per cent of the total security holdings, however, and therefore has been deemed a safe arrangement. Recovery effects during the year have indicated that this was a profitable policy.

At the close of the calendar year 1936 the security holdings of the Association were diversified as follows.

Cash—Uninvested and Savings Bank Deposits.....	\$12,207	17.7 per cent
Bonds.....	\$39,574	57.6 per cent
Preferred stocks.....	\$ 2,622	3.8 per cent
Common stocks.....	\$14,364	20.9 per cent

This total market value represents a substantial increase during the year, due largely to higher market at the close of the year.

BUDGET

The probable receipts and expenditures for the fiscal year 1937 have been estimated and a budget has been prepared (Table X). Total revenues have been estimated at \$40,975 and total expenditures at \$40,600.

EXECUTIVE COMMITTEE MEETINGS

In addition to the executive committee meetings at the Tulsa and Los Angeles conventions, quorum meetings were held in Laredo, Texas, on October 17, 1936, and in Cincinnati, Ohio, December 31, 1936, to discuss and transact Association business.

HEADQUARTERS OFFICE

One of the first acts of the present executive committee in March, 1936, was to arrange for more suitable office space for the headquarters staff. Members visiting in Tulsa the past year have commented on the improved arrangement. Although the rent item has been increased considerably the Association is not now dependent upon the contribution of office space by the Chamber of Commerce as it has been since 1926, when a full paid office staff was organized.

During 1936 business manager Hull passed his tenth year in the employ of the Association. Recognition of this faithful and loyal term of service was tendered by the executive committee in an appropriate letter from president Reed.

ACKNOWLEDGMENTS

The treasurer has had the complete coöperation of the executive committee and highly valued advice from the members of the finance committee, and hereby expresses his appreciation of their support. This report would be incomplete without praise of business manager Hull and his headquarters staff in carrying on so efficiently the routine business of the Association.

CHARLES H. ROW, *secretary-treasurer*

TABLE I
TOTAL MEMBERSHIP BY YEARS

May 19, 1917.....	94	March 1, 1928.....	1,952
February 15, 1918.....	176	March 1, 1929.....	2,126
March 15, 1919.....	348	March 1, 1930.....	2,292
March 18, 1920.....	543	March 1, 1931.....	2,562
March 15, 1921.....	621	March 1, 1932.....	2,558
March 8, 1922.....	767	March 1, 1933.....	2,336
March 20, 1923.....	901	March 1, 1934.....	2,043
March 20, 1924.....	1,080	March 1, 1935.....	1,973
March 21, 1925.....	1,253	March 1, 1936.....	2,169
March 20, 1926.....	1,504	March 1, 1937.....	2,331
March 1, 1927.....	1,670		

TABLE II
COMPARATIVE DATA OF MEMBERSHIP

	March 1, 1936	March 1, 1937
Number of honorary members.....	11	14
Number of life members.....	2	2
Number of members.....	1,732	1,885
Number of associates.....	424	430
Total number of members and associates....	2,169	2,331

TABLE II (Continued)

	March 1, 1936 196	March 1, 1937 162
Increase in membership.....		
Members and associates.....	140	166
Reinstatements.....	148	88
Total new members and reinstatements.....	288	254
Applicants elected, dues unpaid.....	11	19
Applicants approved for publication.....	20	36
Recent applications.....	31	41
Total applications on hand.....	62	96
Applicants for reinstatement, elected, dues unpaid.....	8	14
Recent applicants for reinstatement.....	10	8
Total applications for reinstatement on hand.....	18	22
Applicants approved for transfer, dues unpaid.....	7	7
Applicants for transfer approved for publication.....	19	11
Recent applications for transfer on hand.....	26	5
Number of members and associates withdrawn.....	3	7
Number of members and associates dropped.....	82	72
Number of members and associates died.....	7	13
Total loss in membership.....	92	92
Total gain in membership.....	196	162
Number of members and associates in arrears, previous year.....	129	51
Members in arrears, current year.....	497	656
Associates in arrears, current year.....	142	158
Total number members and associates in arrears current year.....	639	814
Total number members and associates in good standing.....	1,401	1,486

TABLE III
GEOGRAPHIC DISTRIBUTION OF MEMBERS

March 1, 1937					
Alabama.....	1	Louisiana.....	100	Ohio.....	9
Arizona.....	2	Maine.....	1	Oklahoma.....	436
Arkansas.....	6	Maryland.....	4	Oregon.....	1
California.....	271	Massachusetts.....	8	Pennsylvania.....	40
Colorado.....	38	Michigan.....	24	South Carolina.....	1
Connecticut.....	4	Minnesota.....	3	South Dakota.....	2
Delaware.....	1	Mississippi.....	5	Tennessee.....	5
Dist. of Columbia.....	32	Missouri.....	20	Texas.....	748
Florida.....	6	Montana.....	10	Utah.....	6
Illinois.....	26	Nebraska.....	7	Virginia.....	1
Indiana.....	4	New Jersey.....	9	Washington.....	3
Iowa.....	6	New Mexico.....	21	West Virginia.....	16
Kansas.....	109	New York.....	63	Wisconsin.....	2
Kentucky.....	6	North Carolina.....	2	Wyoming.....	13
Total members in United States.....				2,072	

TABLE III (Continued)

Africa.....	3	Dom. Republic.....	1	New Zealand.....	1
Arabia.....	5	Egypt.....	1	Palestine.....	1
Argentina.....	13	England.....	16	Peru.....	2
Australia.....	11	France.....	5	Philippine Is.....	1
Austria.....	1	Germany.....	11	Poland.....	1
Belgium.....	1	Holland.....	14	Roumania.....	9
Brazil.....	2	Hungary.....	1	Scotland.....	4
B. West Indies.....	6	Iraq.....	4	Spain.....	1
Canada.....	15	Italy.....	2	Sweden.....	1
Colombia.....	14	Japan.....	2	Switzerland.....	9
Cuba.....	2	Madagascar.....	1	Turkey.....	3
Czechoslovakia.....	1	Mexico.....	26	U.S.S.R.....	2
Dutch East Indies.....	15	New Guinea.....	2	Venezuela.....	49
Total members in foreign countries.....			259		
Grand total.....			2,331		

TABLE IV
COMPARISON OF ACCRUED INCOME BY CALENDAR YEARS

Dues	1934	1935	1936
Members.....	\$17,472.00	\$15,860.00	\$18,410.00
Associates.....	2,644.00	2,884.00	3,042.00
Total.....	\$20,116.00	\$18,744.00	\$21,452.00
Bulletin			
Subscriptions.....	\$ 3,414.83	\$ 3,554.04	\$ 4,072.64
Advertising.....	2,524.90	4,628.46	5,994.34
Total.....	\$ 5,939.73	\$ 8,182.50	\$10,066.98
Back Numbers, etc.			
Bound Volumes.....	\$ 1,677.24	\$ 2,249.76	\$ 2,449.84
Back Numbers.....	391.44	738.14	1,097.87
Other Publications.....	21.69	23.50	55.33
Total.....	\$ 2,090.37	\$ 3,025.90	\$ 3,603.04
Special Publications			
Continental Drift*.....	\$ —	\$ —	\$ —
Structure Volume I*.....	411.28	549.26	621.53
Structure Volume II.....	425.88	629.71	697.36
Geology of California*.....	946.35	682.15	578.05
Problems of Petroleum Geology.....	5,181.26	1,917.21	1,200.88
Geology of Natural Gas.....	—	4,353.40	2,131.65
Geology of Tampico Region.....	—	—	1,633.60
Total.....	\$ 6,964.77	\$ 8,131.73	\$ 6,863.67
Other Income			
Convention Receipts (Net).....	\$ —	\$ 70.50	\$ 112.51
Delinquent Dues Charged Off.....	2,509.68	2,820.00	567.00
Interest.....	1,579.83	1,504.71	1,749.67
1.....	61.02	61.79	63.05
*.....	572.19	719.65	519.36
Miscellaneous.....	82.39	138.96	32.05
*.....	5.29	7.50	—
Sale of Library.....	—	—	535.25
Members Reinstated.....	—	—	167.85
Bad Debt Expense.....	—	—	257.33
Cancellation Investment Reserve.....	—	—	1,895.41
Total.....	\$39,921.27	\$43,407.24	\$47,885.77

* Income of Publication Fund

1 Income of Research Fund

TABLE V
COMPARISON OF ACCRUED EXPENSES BY YEARS

	1934	1935	1936
<i>General and Administrative Expenses</i>			
Salaries—Manager.....	\$ 1,670.83	\$ 2,081.32	\$ 1,783.04
Clerical.....	4,800.29	5,541.48	5,459.08
Rent.....	325.00	600.00	1,120.00
Telephone and Telegraph.....	297.78	361.84	342.35
Postage.....	991.53	1,389.90	1,117.32
Office Supplies and Expenses.....	389.61	476.16	813.31
Printing and Stationery.....	147.57	388.43	321.47
Executive Expense.....	—	151.69	—
Audit Expense.....	450.00	300.00	300.00
Insurance and Taxes.....	92.50	155.28	163.58
Convention Expense.....	94.39	—	—
Freight and Express.....	48.00	104.99	178.76
Exchange and Refunds.....	17.13	—	13.97
Bad Debts.....	—	43.40	—
Donations—Soc. Econ. Paleon. and Min....	354.00	530.00	500.00
Soc. Pet. Geophysicists.....	—	250.00	—
Nat. Research Council.....	—	250.00	250.00
Research Committee Expense.....	—	57.60	—
Miscellaneous.....	69.23	26.73	14.51
Depreciation—Furn. and Fixtures.....	333.37	384.86	374.07
Investment Counsel.....	—	—	200.00
Loss on Bonds, etc. (Net).....	—	—	28.98
Total.....	\$10,081.23	\$13,093.68	\$12,980.44
<i>Publication Expenses</i>			
Salaries—Manager.....	\$ 2,500.00	\$ 2,500.00	\$ 2,700.00
Editorial.....	3,281.20	3,414.40	1,550.60
Printing Bulletin.....	8,589.11	10,468.02	11,554.05
Engravings.....	1,454.43	1,965.41	1,694.44
Separates.....	276.92	394.66	261.98
Stencils and Mailing.....	138.20	146.30	167.47
Binding Bulletins.....	504.35	362.69	341.75
Postage and Express (Bulletins).....	714.57	762.56	801.89
Copyright Fees.....	24.00	24.00	24.00
Freight and Express.....	606.48	311.30	677.64
Discounts.....	56.15	63.85	78.00
Purchase of Back Numbers.....	3.50	250.40	49.00
Bad Debts.....	—	40.50	97.40
Miscellaneous.....	26.91	32.31	244.81
Special Publications.....	6,270.01	9,774.99	6,830.69
Refunds—Unavailable Bulletins.....	—	—	347.00
Obsolescence of Printed Matter.....	—	—	319.05
Bulletin Inventory Decrease.....	—	—	2,597.80
Total.....	\$24,445.83	\$30,511.39	\$30,337.57
Total Expense.....	\$34,527.06	\$43,605.07	\$43,318.01

TABLE VI
COMPARISON OF NET INCOME BY YEARS

	1934	1935	1936
Accrued Income.....	\$39,921.27	\$43,407.24	\$47,885.77
Expenses			
General and Administrative.....	10,081.23	13,093.68	12,980.44
Publication.....	24,445.83	30,511.39	30,337.57
Total.....	\$34,527.06	\$43,605.07	\$43,318.01
Excess Income over Expenses.....	5,394.21	—197.83	4,567.76

TABLE VII
INVESTMENTS

	Cost	Market Value End of Year
<i>1934 Values</i>		
General Fund.....	\$39,259.78	\$34,340.73
Publication Fund.....	16,374.91	13,517.77
Research Fund.....	1,412.55	1,185.05
Total.....	\$57,047.24	\$49,043.55
<i>1935 Values</i>		
General Fund.....	\$26,531.33	\$25,423.50
Publication Fund.....	14,435.02	12,568.47
Research Fund.....	1,416.72	1,396.72
Total.....	\$42,383.07	\$39,388.69
<i>1936 Values</i>		
General Fund.....	\$41,707.03	\$43,255.77
Publication Fund.....	12,635.94	14,097.03
Research Fund.....	1,480.16	1,568.15
Total.....	\$55,823.13	\$58,920.95

TABLE VIII
COMPARISON OF COST OF BULLETIN

	1934	1935	1936
Total Expenses.....	\$18,213.19	\$19,707.66	\$18,994.39
Monthly Edition.....	2,845-2,700	3,000	3,200
Total Copies Printed.....	33,096	35,951	38,400
Total Pages Printed, Including Covers.....	2,024	2,236	2,094
Total Pages of Text.....	1,737	1,868	1,722
Total Cost per Copy.....	0.55	0.55	0.50

TABLE IX
SPECIAL PUBLICATIONS

	Structure Vol. I	Structure Vol. II	Geology Calif- ornia	Problems Petrol. Geology	Geology Natural Gas	Geology Tampico Region	Total
Inventory 12-31-35.....	\$375.39	\$1,780.20	\$314.35	\$1,672.65	\$5,562.60	—	\$9,714.19
12-31-36.....	60.84	1,357.20	81.88	958.75	4,352.00	2,404.50	9,224.17
Sales 1936.....	621.53	997.36	578.65	1,200.88	2,131.65	1,033.60	6,863.67
Total Edition.....	2,300	2,500	1,300	2,634	2,500	1,575	—
Copies on Hand 12-31-35.....	129	497	177	567	1,534	—	—
12-31-36.....	24	377	46	325	1,088	1,050	—
Number of Pages.....	510	780	355	1,073	1,227	280	—
Cost (Inventory) per Copy.....	\$2.91	\$3.60	\$1.78	\$2.95	\$4.00*	\$2.29	—
Selling Price When Issued, per Copy.....	4.00	4.00	4.00	5.00	4.50	3.50	—
Present Selling Price.....	—	—	—	—	—	—	—
Members and Associates.....	5.00	5.00	5.00	5.00	4.50	3.50	—
Non-Members.....	7.00	7.00	5.00	6.00	6.00	4.50	—

* Increased cost due to higher cost of binding 1,000 unbound copies.
NOTE: The books, *Structural Evolution of Southern California* and *Gulf Coast Oil Fields*, were not billed to Association or distributed in calendar year 1936.

THE ASSOCIATION ROUND TABLE

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TABLE X
BUDGET, 1937

	1936	1937 Estimate
Revenues		
Dues.....	\$21,452.00	\$21,500.00
Bulletin		
Subscriptions.....	4,072.64	4,225.00
Advertising.....	5,994.34	6,000.00
Bound Volumes.....	2,449.84	2,500.00
Back Numbers.....	1,097.87	750.00
Special Publications		
Structure Volume I.....	621.53	100.00
Structure Volume II.....	697.36	500.00
Geology of California.....	578.65	200.00
Problems of Petroleum Geology.....	1,200.88	850.00
Geology of Natural Gas.....	2,131.65	1,000.00
Geology of Tampico Region.....	1,633.60	500.00
Other Publications.....	55.33	50.00
Other Income		
Delinquent Dues Charged Off.....	567.00	500.00
Interest.....	2,332.68	2,000.00
Miscellaneous.....	144.56	100.00
Sale of Library.....	\$ 535.25	
Cancellation of Reserve on Investments.....	1,895.41	
Bad Debts Exp.....	257.33	
Members Reinstated.....	167.85	
Total.....	\$47,885.77	\$40,975.00
Expenses		
General and Administrative.....	\$12,980.44	\$11,000.00
Refunds on Bulletins.....	347.00	—
Publication Expense.....	26,541.46	26,500.00
Geology of Tampico Region.....	3,449.11	—
Comprehensive Index (Printing only).....	—	2,700.00
Structural Evolution of Southern California.....	—	400.00
Total.....	\$43,318.01	\$40,600.00
Surplus.....	—	\$ 375.00

EXHIBIT III. REPORT OF EDITOR

Statistical information concerning the *Bulletin* for 1936 is submitted in tabular form herewith. It should be noted that the total number of pages was 1,722, an average of 143 pages per month. This is a decrease of 467 pages for the year or 39 pages per month from the *Bulletin* for 1935. At that, every available contribution was published, and the issues for April and May, 1937, which must be prepared by the outgoing editorial staff, were secured only by considerable use of the telegraph on the part of the business manager and by reducing the editorial reading to a minimum.

During 1936, two special publications were issued: the *Geology of the Tampico Region* by John M. Muir; and the *Gulf Coast Oil Fields*, a compilation of papers previously published in the *Bulletin*, which were in large part secured for publication through the efforts of the editors of the volume, Donald C. Barton and George Sawtelle. The Association certainly owes much to the authors and editors of these special volumes for their contribution of time and effort. These volumes have been well received, as is shown by the detailed reports of other officers.

A considerable departure from established *Bulletin* practice was the publication of the *Structural Evolution of Southern California* by R. D. Reed and J. S. Hollister as a special number (December, 1936, issue) of the *Bulletin*. This work of more than 170 pages, profusely and excellently illustrated, and with a large, colored map insert, easily deserved publication as a special volume; and the editor is particularly grateful to the authors for yielding to the need of material for the *Bulletin* and permitting its publication in *Bulletin* form. At the same time, the executive committee feels what it hopes is a pardonable pride in furnishing all members a work of this caliber at no extra cost. Clothbound copies for sale to non-members, and to members desiring an additional copy of the work in this form, have had a sale even exceeding our not extremely modest expectations.

The compilation of a *Comprehensive Index* of the publications of the Association has been completed by Miss Heath of the Tulsa staff, and it is hoped that a few copies will be available for inspection at this meeting. Paperbound copies of this 382-page index will be furnished the membership free of charge, and additional clothbound copies will be available to members and others. The Index will certainly prove to be of great value, and is a fitting memorial to the completion of our twentieth year as an organization.

At the end of my four years as editor, I wish to express my deep appreciation of the confidence the Association has placed in me, and of my association with other members of the different executive committees with whom I have served. I wish also to acknowledge my debt to my associate editors and to the headquarters staff at Tulsa. The work of the editorial staff at headquarters is performed so efficiently and so unobtrusively that it is probably taken for granted by the membership, with no definite idea of the amount of detailed work which is necessary in the preparation of manuscripts for the *Bulletin* and their conduct through the press. I but recently realized that, even with my knowledge of the importance of this work and of the way in which it is handled, I also had come to regard it so much as a matter of course that no mention was made of it in my previous annual reports.

As a final word, I wish to re-emphasize what I believe is a very serious situation facing the Association in regard to material for publication. Although a society such as ours has many functions, certainly its fundamental purpose is the accumulation and dissemination of scientific information. The future position and influence of the Association depend largely on the amount and character of its publications. The decrease of 450 pages in the material available for *Bulletin* publication, and the necessity of using what should perhaps have been a special publication for one issue during 1936, should be regarded very seriously, I believe, by every member of the Association. No supply of *Bulletin* material is being turned over to the incoming editor and no special volumes are in immediate prospect, though we have ample funds for publication and a market for such volumes that does not appear to have approached the saturation point.

Certainly, the fields of exploration and investigation in petroleum geology are not exhausted nor approaching exhaustion, so that the shortage of papers for publication is not due to a real scarcity of material, but to the lack of incentive, or of opportunity, to put the material in shape for publication. In my opinion, if the Association is to maintain the standing it has achieved and the standards it has maintained during the past, some way must be found

to supply the incentive and to provide the opportunity for the writing of papers for publication.

L. C. SNIDER, *editor*

PAGES IN BULLETIN, 1936

Total number of pages of majors.....	1,300
Total number of pages of minors.....	422
Total number pages of majors and minors.....	1,722
Total number of Roman pages.....	308
Total number of pages in 1936.....	2,030
Total number of illustrations.....	372
Total number of major articles.....	61
Total number of minor articles*.....	74
Estimated number of pages of illustrations.....	310

* Minor Articles: Geological Notes, Discussions, Reviews, Memorials.

1936 BULLETIN

<i>Month</i>	<i>Pp. Majors</i>	<i>Pp. Minors</i>	<i>Pp. Maj. and Min.</i>	<i>Roman</i>	<i>Total Pp.</i>
January.....	101	23	124	24	148
February.....	101	19	120	24	144
March.....	67	73	140	24	164
April.....	93	43	136	24	160
May.....	91	65	156	24	180
June.....	139	33	172	24	196
July.....	126	30	156	24	180
August.....	117	39	156	24	180
September.....	89	27	116	28	144
October.....	95	17	112	24	136
November.....	105	35	140	32	172
December.....	176	18	194	32	226
Total.....	1,300	422	1,722	308	2,030
Monthly average.....	108.3	35.1	143.5	25.6	169.1

1936 BULLETIN ILLUSTRATIONS

<i>Month</i>	<i>No. of Illustrations</i>	<i>Est. Pp. Illustrations (Full Page Space)</i>
January.....	29	16
February.....	29	21
March.....	1	$\frac{1}{2}$
April.....	16	19 $\frac{1}{2}$
May.....	39	39
June.....	31	25 $\frac{1}{2}$
July.....	50	36
August.....	29	20
September.....	23	18
October.....	17	12
November.....	36	25
December.....	72	77 $\frac{1}{2}$
Total.....	372	310
Monthly average.....	31	25.8

EXHIBIT IV. REPORT (MINUTES) OF GENERAL BUSINESS COMMITTEE

Biltmore Hotel, Los Angeles, California, March 16, 1937

The meeting was called to order at 2:15 P.M. by Thornton Davis, chairman.

The following members were present.

Executive committee: R. D. Reed, Chas. H. Row, A. I. Levorsen, C. E. Dobbin

Members-at-large: E. DeGolyer, Ed. W. Owen, R. W. Clark, Frank Rieber

Division of Paleontology: Not represented

Division of Geophysics: Gerald H. Westby represented by B. B. Weatherby

District Representatives:

Amarillo, not represented

Appalachian, not represented

Canada, not represented

Capital, A. A. Baker represented by Parker D. Trask

Dallas, R. E. Rettger represented by Wallace Ralston

East Oklahoma, Ira H. Cram

Fort Worth, H. B. Fuqua

Great Lakes, not represented

Houston, Kenneth Dale Owen, J. Brian Eby

Mexico, not represented

New Mexico, not represented

New York, R. F. Baker

Pacific Coast, Roy M. Barnes, Louis N. Waterfall, Harold W. Hoots

Rocky Mountain, J. Harlan Johnson represented by C. E. Dobbin

San Antonio, Thornton Davis

Shreveport, not represented

South America, not represented

So. Permian Basin, Robert L. Cannon represented by C. A. Mix

Tyler, E. A. Wendlandt

West Oklahoma, not represented

Wichita, Clare J. Stafford represented by L. C. Morgan

Wichita Falls, not represented

1. *Minutes of previous meeting.*—It was moved, seconded, and carried that the reading of the minutes of the last meeting of the committee be omitted, as the minutes had been published in the *Bulletin*.

The reports of the following committees were read.

2. *Report of the committee on geologic names and correlations*, Ira H. Cram, chairman.

3. *Report of committee on applications of geology*, Frank R. Clark, chairman.

The following motion was made, seconded, and carried: That any committee of the Association whose appointment and tenure of office are not specifically prescribed by the Constitution and By-Laws be subject to expiration annually.

4. *Report of representative of Association on Division of Geology and Geography, National Research Council*, F. H. Lahee, representative.

5. *Report of the research committee*, Donald C. Barton, chairman.

After reading of the reports it was moved, seconded, and carried that the reports be accepted and referred to the annual business meeting with the recommendation that they be not read but that they be published in the May, 1937, *Bulletin*.

The following resolutions were moved, seconded, and adopted.

6. *Dissolution of the Society of Petroleum Geophysicists.*—That the application of the Society of Petroleum Geophysicists for dissolution as a technical

division of the Association be approved and recommended to the annual business meeting.

7. *Society of Exploration Geophysicists*.—That the application of the Society of Exploration Geophysicists to become affiliated with the Association be approved and recommended to the annual business meeting.

8. *Michigan Geological Society*.—That the application of the Michigan Geological Society to become affiliated with the Association be approved and recommended to the annual business meeting.

9. *South Louisiana Geological Society*.—That the application of the South Louisiana Geological Society to become affiliated with the Association be approved and recommended to the annual business meeting.

10. *Southwestern Geological Society (Austin, Texas)*.—That the application of the Southwestern Geological Society to become affiliated with the Association be approved and recommended to the annual business meeting.

11. *Division of Paleontology*.—That the customary annual contribution of \$500.00 be paid by the Association to the Society of Economic Paleontologists and Mineralogists for the support of their publication program during 1937.

12. *South Texas Geological Society*.—That the application of the San Antonio Geological Society to change its name to the South Texas Geological Society and the name of the San Antonio Section to the South Texas Section be approved and recommended to the annual business meeting.

The meeting of the general business committee adjourned at 4:00 P.M.
 THORNTON DAVIS, *chairman* CHARLES H. ROW, *secretary*

EXHIBIT V. REPORT OF COMMITTEE ON GEOLOGIC NAMES AND CORRELATIONS

During the past year the committee studied and made recommendations upon the following papers.

- H. A. IRELAND, Use of Insoluble Residues for Correlation in Oklahoma
- HORACE D. THOMAS, Frontier-Niobrara Contact in Laramie Basin, Wyoming
- W. M. FURNISH, E. J. BARRAGY, AND A. K. MILLER, Ordovician Fossils from Upper Part of Type Section of Deadwood Formation, South Dakota
- DARSIE A. GREEN, Permian and Pennsylvanian Sediments Exposed in Central and West-Central Oklahoma
- GLENN GRIMES, Revision of Pennsylvanian-Permian Contact on North American Continent
- CONSTANCE LEATHEROCK, Physical Characteristics of Bartlesville and Burbank Sands in Northeastern Oklahoma and Southeastern Kansas
- ROBERT ROTH, Notes on the Custer Formation of Texas
- R. B. RUTLEDGE AND HOWARD S. BRYANT, The Cunningham Oil Field, Kingman County, Kansas

The committee recommends the publication of more papers dealing with the simplification of the stratigraphy of any given area. Many authors are prone to invent new names without due consideration of the possible confusion they may be causing by so doing. The committee recommends as sound practice extreme caution in the invention of new names, and further recommends that all authors discuss their problems of nomenclature and correlations with the committee before presenting their papers to the editorial staff for publication.

One member of the committee, John G. Bartram, is laying the groundwork for future studies in his paper on the Upper Cretaceous of the Rocky

Mountain Area, which he is presenting at this convention. He reviews the problem and recommends a simplification of the Upper Cretaceous nomenclature. The chairman of the committee is a member of a national committee headed by Carl O. Dunbar of Yale University, which committee is making an exhaustive study of the Permian of the United States. Undoubtedly the final report of this committee will have simplified the stratigraphy of the Permian. The committee commends Dr. Reed's treatment of the stratigraphy of California in his papers on California geology.

IRA H. CRAM, *chairman*

EXHIBIT VI. REPORT OF CHAIRMAN OF RESEARCH COMMITTEE

The work of the research committee during the past year has been routine.

The annual dinner and open meeting of the committee were held at Tulsa as usual on the Wednesday evening preceding the opening of the annual meeting of the Association. The key subject of discussion was "Variation of Occurrence and Character of Oil and Gas with Variation of Stratigraphic Facies." The problem is one of fundamental importance in oil geology but no one has done much work on it. The attendance at the meeting was more than two hundred. The discussion was active. The annually growing popularity of this open meeting of the research committee would seem to indicate a call for such an informal meeting with unrestrained and only slightly directed discussion in the program of the annual convention. The open meeting is no longer the simple round-table discussion which it was meant to be. I still believe in the value of a group of the more philosophical oil geologists getting together around a figurative round table and informally discussing the fundamental problems of oil geology. Discussion is much more free at such a small gathering than it ever can be with an audience of several hundred.

No mid-year meeting of the research committee was held this year. The question of the desirability of mid-year meetings is perplexing. The discussions at them would be stimulating and worth while, but with the annually growing importance of the annual meetings of the local societies such as the San Antonio, Shreveport, and Kansas geological societies, and the mid-year meeting of the production section of the A.I.M.E., practically, it is getting difficult to get away for another meeting, and it is difficult to get a sufficient number of the members of the committee together to make a mid-year meeting worth while.

Many members of the committee as usual served as advisers to younger men in the preparation of papers.

The study group of the Houston Geological Society has continued to hold the interest of its members and has continued to hold its meetings throughout the past year. I would like again to recommend the formation of such study groups to the members of other local societies.

I would like again to call the attention of the members of the Association to the Division of Geology and Geography of the National Research Council. The Division, in a way, is the National Research Committee in geology and geography. It is sponsoring much effective coöperative research on a wide range of fundamental geologic and geographic problems. Many of its projects are of high interest to the members of the Association. The Division publishes an annual report which includes progress and in some cases final reports by the respective chairmen of the committees on the various projects, and which

can be obtained from the chairman, Division of Geology and Geography, National Research Council, National Academy of Science Building, Constitution Avenue, Washington, D. C. This report is worthy of the attention and interest of the members of the Association. The Division is an important force in geologic research in this country and the liaison between the Association and the Division should be closer. The National Research Council also has an important inter-divisional committee which is interested in borderline problems involving more than one science. The committee is meditating on at least one problem which will require the coöperation of oil geologists and oil companies. I would like to commend the committee to them.

In recommending the Division to the members of the Association, I should like also to recommend the American Geophysical Union to their attention. The Union is a semi-independent society which is sponsored by the National Research Council and which functions much as a division of the Council. The work of many of its committees should be of interest to members of the Association.

Although much interested in the research work of the Association, the Division on the whole is rather poorly informed in regard to the geologic research work which is being done by the oil industry. The Association representative on the Council, F. H. Lahee, and I are in agreement that the extent of geologic research work by the oil industry should be brought more clearly to the knowledge of the Division. With his assistance and with the assistance of other members of the research committee and other colleagues, I have compiled the appended report on "The State of Geologic Research in the Oil Industry."

DONALD C. BARTON, *chairman*

EXHIBIT VI—A. THE STATE OF GEOLOGIC RESEARCH IN THE OIL INDUSTRY

The extensiveness of the geologic research by the American oil industry probably is realized by few persons not directly in contact with exploration for oil in United States. The time collectively spent annually by the American oil industry on work that extends the limits of geologic knowledge is equivalent to that which would be spent by 1,500 geologists working for one year wholly on research. Part of that 1,500 man-years of work is devoted to pure research on fundamental or broad problems. Part is done by engineers and geophysicists on problems near the border line of geologic interest. More than half of those 1,500 man-years of time is spent on routine, often more or less exhaustive, practically always repetitive determination of simple geologic facts that is not regarded as research by the oil geologist; it probably would be regarded as research by many college geologists, but the abler research geologists probably would term it "hack" research. Much of the work is done over and over again independently by the men of different companies but in spite of being commercial competitors, most of those men working on the same problem do much swapping of data and comparison of results. Much of the work is mediocre. Nevertheless, the oil industry is accumulating an enormous store of geologic information in regard to the petroliferous areas and is doing a good work in successfully elaborating the concealed (as well as the unconcealed) geology and geologic history of wide areas.

The geological and semi-geological research that is done in connection with the oil industry may be classified crudely and somewhat arbitrarily into the following four groups.

- A. Organized research, mainly by the oil companies, but also by schools, state and federal surveys, and bureaus which serve the oil business
- B. Routine work which partakes in considerable part of the nature of research
- C. Research by individuals on their own initiative
- D. Symposia

A. ORGANIZED RESEARCH

The organized research is concerned mainly, in order of decreasing intensity, with:

- I. Petroleum production engineering
- II. Geophysical prospecting
- III. Stratigraphy and paleontology
- IV. Miscellaneous research

I. Petroleum production engineering

Research in all phases of petroleum engineering has become increasingly active during the past five years; and the organized research in it at the present time probably exceeds all the rest of the organized research on geological and geophysical problems in connection with exploration and production of oil.

Nearly all phases of the conditions prevailing in the formations from which he must produce his oil and gas interest the petroleum production engineer. Much attention, therefore, is being paid by petroleum production engineers to the following problems.

1. Porosity and permeability in formations containing oil and gas (and in formations to which waste salt water must be introduced or in which gas must be stored).

2. Temperature and pressure prevailing in the liquids and gases in the producing reservoir. Temperature and pressure critically affect the conditions of equilibrium and the behavior of oil, gas, and water in the reservoir. Measurements of "bottom-hole pressure" and temperature, therefore, are coming to be routine in oil fields. A report of 139 pages on "Earth Temperatures in Oil-fields" was published in 1930 by the American Petroleum Institute as the result of one of its research projects, but the report already is obsolete on account of the vast subsequent accumulation of data.

An interesting result of the pressure studies in the Gulf Coast is the determination that pressures, 25 to 40 per cent above hydrostatic pressures, are common although not the rule in the liquids and gases of the producing sands.

3. Conditions of flow of liquids and gases, particularly of crude oil and petroleum gas, through sands.

4. Connate water in oil sands.

In many places throughout the world, sands producing oil and gas clean of water are being found to have 35 to 50 per cent of their pore space filled with water.

Considerable study is being made, in part experimentally, in regard to the effects of varying porosity, permeability, and quantity of connate water on the movement of oil in the oil sand.

5. Properties of oil and gas under reservoir conditions of temperature and pressure.

6. Reactions taking place in oil reservoirs.
7. Much study on the improvement of techniques in obtaining data.
8. Colloidal chemistry of drilling-mud and of formations exposed to drilling-muds. Drilling-mud in many areas no longer is just "mud" but is compounded as carefully as a physician's medicinal prescription. The colloidal character of certain formations is extremely important in connection with the heaving shale, which precludes or makes drilling hazardous and expensive in certain areas.

9. Many problems not collateral to geology except in so far as economic geology is interested in the problems of petroleum reserves and in the efficiency of the production of petroleum. Much research also is being done on the mechanical engineering problems of oil production.

Many oil companies maintain research staffs whose attention is devoted primarily to research in petroleum engineering. Many petroleum engineers who are not assigned primarily to research, nevertheless, are doing considerable organized research. The department of production research of one oil company has a staff of twelve engineers and scientists and a few additional less well trained men for routine tasks. The headquarters central research group of another company has five physicists and three chemists engaged wholly on research in petroleum engineering. The U. S. Bureau of Mines maintains petroleum experiment stations and carries on a modest program of petroleum production research. The petroleum engineering departments of such schools as the University of Oklahoma and the University of Texas are doing considerable research. Important research is being carried on under Lewis at M. I. T. and by Lacey at California Tech.

A rather ambitious program of research on fundamental problems of the oil industry was fostered by the American Petroleum Institute for some years after 1928 and a reduced program has been continued for the past few years. Part of the projects concerned petroleum production engineering.

A by-product of all this primarily non-geologic research, however, is the accumulation of a vast store of geological information in regard to conditions in the subsurface.

II. *Geophysical prospecting*

Several companies in the United States are spending \$100,000 to \$250,000 each per year routinely on geophysical research. Some of the consulting geophysical companies are expending lesser but still considerable sums of money on research. One company has a staff of twelve physicists and mathematical physicists, and one physical chemist working solely on research on geophysical exploration; and many of these men have a Ph.D. At least two other companies have comparable research staffs in geophysical prospecting.

The bulk of the geophysical research is in connection (a) with instrument design, and (b) with methods.

The re-design of the seismic equipment goes on constantly. As the more easily found structures become discovered, both instruments and technique have to be refined and improved, if more difficult situations are to be handled. For certain purposes, improved instrumental equipment and the old technique are sufficient; for other purposes, modified technique is necessary and requires re-design of part of the instrumental equipment.

Highly successful research has been and is being done on the measurement of gravity. The improved gravimeter is one of the great contributions

of oil-company research to geology. In the standard work by Geodetic Surveys, the accuracy of the measurement of gravity has been $p.e. = \pm 0.001$ gal; and during the past few years, the time necessary for an observation has been reduced from several days to one day. Oil-company geophysical departments have improved the pendulum observations so that the accuracy is $p.e. = \pm 0.0004$ or possibly ± 0.0003 gal and several stations can be occupied per day. But at the present moment, the pendulum seems to be going to be eliminated permanently by the gravimeters. Under the stimulus of geophysical exploration, several gravimeters have been perfected which have an accuracy better than $p.e. = \pm 0.0003$ gal and some of which can take twenty to thirty stations per day. The field accuracy of the best gravimeters is $p.e. = \pm 0.0001$ gal; the time necessary for the occupation of a station with it is less than ten minutes; and the cost per station in ordinary Texas terrane is \$4.50, inclusive of the cost of instrumentally run levels. The present disadvantage of most of the better gravimeters known to me is a shift of the zero point that forces a checkback to the day's base station at least once a day and which precludes considerable time intervals between stations and between taking off from, and checking back on a base station.

Much research is also being done on instruments in electrical prospecting.

One third or more of the organized geophysical research of the oil companies and consulting companies is devoted to the attempted development of new methods or of new techniques in the standard methods. Active subjects of research at the present time are the following.

(a) Techniques for the identification of faults by the reflection seismic method.

(b) Smoothing of shallow depth effects in the records by using many more detectors than galvanometer strings and using various types of hook-ups of the detectors.

(c) Recording the seismogram on sound-track film and analyzing the records by running them in different combinations through a sound machine and recording the resultant as a new seismogram.

(d) Chemical and electroscopic analysis of gas from the surface soil.

(e) Chemical analysis of gas from gas seeps for the ratio of light to heavy hydrocarbons.

(f) Various electrical methods of electrical prospecting at the surface.

(g) Electrical logging of wells.

This electrical method of logging wells is another one of the contributions of oil business to geology. The standard Schlumberger electrical well log gives the variation of resistivity and the variation of porosity. By using the combination of porosity and resistivity, a great deal can be told about the formations through which the well has passed. These logs give the geologist a stratigraphic record which excels anything which he has ever had for combined continuity and detail. In many areas, electrical logs are run of all wildcat wells from the surface to the bottom of the hole, and in many semi-wildcats, or wells in some proved oil fields, for the lower part of the well.

(h) Techniques for seismic mapping of the basement at depths of 20,000 feet plus. The surface of the basement underneath a thick sedimentary prism theoretically should be a surface of considerable seismic discontinuity and should give greater structural relief to many structures than considerably shallower horizons. Considerable experimentation, therefore, has been and is

being done on getting reflections from the basement at depths of 20,000 feet or more.

(i) Magnetic determination of the orientation of cores containing at least a moderate content of magnetic material is reported to show a little permanent magnetism oriented according to the earth's magnetic field; and that magnet, set in the formations, is reported to be usable to determine the original orientation of the material of the core in the subsurface.

A modest amount of research is being done on the interpretation of geophysical data after they have been obtained. But I have never ceased to be astounded at the small amount of attention which the oil companies, as a whole, have paid to research on the interpretation of the observed geophysical data compared to that which they have devoted to research on the instruments necessary to obtain the data.

The total organized geophysical research has led to the contribution of powerful tools to the geologist and it has also inspired some of the research geophysicists and physicists to important contributions to pure geology, as for example, Nettleton's important paper on the mechanics of the growth of salt domes. I have hopes that others of the able research physicists and geophysicists will become increasingly interested in the dynamical problems of geology.

III. *Stratigraphy and paleontology*

A modest amount of organized research is being done on stratigraphy and paleontology in addition to the much greater amount which is done in the course of routine work. The Humble Oil and Refining Company, for example, has a senior geologist and an assistant assigned exclusively to stratigraphic research and one paleontologist assigned exclusively to the description of fossils. Many geologists take a little time out now and then from regular work for research on stratigraphy. Many paleontologists spend their vacations on collecting trips. But, in the main, most company geologists who deal with stratigraphy and most company paleontologists work under such pressure that they have time only for part of the stratigraphic and paleontologic research immediately and urgently necessary.

Most of the state geologic surveys and geologic departments of universities in the oil producing states are carrying on organized programs of stratigraphical and paleontological research, which draw much informal aid and assistance from the oil geologists and the work of the oil companies.

Considerable cooperation has been carried on between the oil geologists, and state and federal geologic surveys in the compilation of state and areal geologic maps for publication. Much of the areal geology of the U. S. Geological Survey's geologic map of Oklahoma and much of the Survey's about-to-be-published geologic map of Texas were contributed by the oil companies.

The blue print county areal geologic maps which the Bureau of Economic Geology in Texas has available for much of central Texas were compiled in the main by the cooperative work of oil geologists from oil company data. Many of the bulletins of the Oklahoma, Texas, and Louisiana geological surveys are based mainly on the geological work of oil companies.

Many companies in the past have carried on research in regard to the use of heavy minerals, composition of sands in terms of sand grains, etc., in the search of effective criteria for correlation.

IV. Miscellaneous research

1. The extensive A.P.I. research program of several years ago on fundamental problems of the oil industry comprised many projects of geologic or semi-geologic interest.

- (a) Generation of oil in rocks by shearing pressures
- (b) Studies of source rocks in the micro-furnace
- (c) Origin and environment of source sediments present in petroleum
- (d) Diatoms as a source of oil
- (e) Limestones and dolomites as reservoir rocks
- (f) The fundamentals of the retention of oil by sand
- (g) Determination of geothermal gradients in oil fields on anticlinal structure

Most of the projects have been officially terminated and a report of progress or achievement has been published. The project on the source beds of petroleum, one of the most fundamental of the projects, however, is still being pursued actively and has led already to several important reports of progress.

2. Minor research is being done on the interpretation of aerial photo-mosaics.

3. In connection with lawsuits, oil companies occasionally have to make extremely detailed geologic and engineering studies. To prepare its case tried last year in connection with its properties in the West Columbia oil field, The Texas Company had an average of five geologists and petroleum engineers working for four years on the geology of the West Columbia salt dome and of the producing sands and on certain production engineering problems in connection with the field.

B. RESEARCH IN LINE OF ROUTINE WORK

More than 800 man-years of 8 hours per day, 5 days per week, and 50 weeks per year are devoted annually by American oil geologists to constructive geologic work. The figure possibly should be as high as 1,000 man-years. That estimate is based on last year's membership of the American Association of Petroleum Geologists, 2,176 geologists, and on argument with colleagues in regard to the average per cent of the members' time which is spent on constructive geologic work in contrast to time which is spent in trading, in consulting data in connection with trading and in connection with location of wells, *etc.*, in scouting, in non-geologic office work, in conferences not in regard to geology, and so forth. My colleagues' figures were above 50 per cent, but to be conservative, I have used a figure of 40 per cent to allow a factor of safety and to allow for members of the Association who are in schools or not in the oil business. The more than 1,500 man-years of geophysical work which the American oil industry uses in mapping geologic structure are not included in these figures.

These 800 man-years of geologic work are devoted to work that is routine to an oil company and not regarded as research, but that in college work would be regarded as research, although in considerable part as rather hack research. That work comprises the following.

(a) Surface mapping varying in grade from simple reconnaissance for dip, strike, and faults to: (1) careful areal mapping of the surface geology; and (2) careful instrumental mapping of the elevation of key beds, or of contacts with the resultant mapping of even faint variations of structure. I have the

impression that few European geologists and many American college geologists have no idea of the precision with which the surface structure has been mapped in wide areas of the oil-field regions of United States.

(b) Sufficient working out of the surface section to carry on that surface mapping.

(c) Use of physiography, of topographic maps, and of aerial photo-mosaics to get clues to geologic structure.

(d) Use of core test holes to map shallow datum horizons in order to map shallow concealed structure.

(e) Three-dimensional stratigraphic correlation.

The Humble Oil and Refining Company's Houston laboratory handles 1,200 samples per day from the Gulf Coast (Mexico to Florida) and East Texas; and attempts stratigraphic determination of the sample; an additional 1,000 to 1,500 samples are handled daily by the district laboratories of the company.

(f) Markers, key fossils, and faunal assemblages, which can be used in correlation.

(g) Use of electrical logs, mainly Schlumberger logs, in correlation.

Few college geologists realize the high importance of the electrical logs and the high added power that they give in working subsurface structure. I rate the introduction of the Schlumberger electrical log as an event almost as important as that of the introduction of all the geophysical methods of prospecting.

(h) Construction of regional structure contour maps commonly on a series of horizons.

(i) Working up the structural geology of oil fields with the construction of structure-contour maps, and structure sections.

(j) Construction of convergence maps.

(k) Construction of isopach maps.

(l) Studies of regional structure and regional structural trends.

Of these 800 man-years, 500 probably are spent on subsurface correlation and the construction of subsurface contour maps.

The oil geologist is getting a three-dimensional picture of large areas that is unexcelled and is equalled only in a few mountainous areas. With scattered wells going below 10,000 feet, a few wells below 12,000 feet, and many wells to 6, 7, and 8,000 feet, with his paleontological and lithological laboratory analysis of the cuttings and cores, and with the great detail of the electric well logs, he is getting a picture of sedimentation throughout a sedimentary basin over a long period of geologic time, in a way that is not available to a geologist not in contact with this oil work. From studies of the surface geology alone, for example, even a surmise would probably never arise in regard to the enormous down-dip thickening of the later Cenozoic beds of the Texas-Louisiana Gulf Coast; or of the Cretaceous beds in the Rio Grande embayment or of some of the Pennsylvanian beds in Oklahoma. He is getting a picture of structures that are different, or a picture that is different, from those obtained by the geologist not in oil work, who in general gets his picture of structure from mountainous regions.

Much, probably most, of this research done in routine work is a little crude or perhaps a better description would be, unfinished or unpolished. The average company geologist works under pressure. He usually has more

tasks waiting to be done or more tasks to do, than he has time for. On account of the exigencies of commercial work, many reports and decisions have to be given by a fixed date on the basis of his best conclusions from the data that he can assemble and analyze by that date, regardless of whether or not he is ready to make a report. His reports commonly are oral or, if written, are merely statements of conclusion. He rarely has time to set down and write a finished, polished report on a piece of work. He seldom has that excellent discipline in rigorous thinking of having to marshal his facts and write out his reasoning in detail in cold black and white. The puncturing of his theories by the drill, however, gives a discipline in cautious theorizing that the college geologist rarely has. But in spite of some imperfections, the store of geologic information in the files of the oil companies is enormous, and I doubt whether many geologists not in contact with geological and geophysical work of the oil industry realize the extent of the unpublished information in the oil companies' files.

The routine geophysical exploration of the oil industry is contributing an enormous amount of information in regard to the deep subsurface.

If the magnetic and gravimetric work of all the companies were combined, complete detailed pictures would be available respectively of the variation of gravity and of terrestrial magnetism from somewhere in Mississippi to the San Carlos Mountains of Tamaulipas, Mexico, for a distance of 100 to 200 miles back from the coast.

The prediction is made by one of my geophysical colleagues that within a very few years, the oil companies will have made a complete gravity map of the Mid-Continent area by use of the gravimeter. Traverses will be run, I imagine, not more than 10 miles apart; and stations will be not more than one to two miles apart; and in many areas, much more detailed surveys will have been made. Much of the Mid-Continent oil province has already been mapped with the vertical magnetometer and the torsion balance.

These regional surveys give much information in regard to the regional structural frame work. They may give much information in regard to major relief on the surface of the basement, regional slope of the basement, and batholithic or other large intrusive masses within the basement. A problem I happen to be working on at the present on the basis of gravity data is the depth (probably 20,000 to 23,000 feet) and relief of the basement in the Gulf Coast of the Houston area.

The reflection seismic method is carrying detailed surveys at depths of, or down to, 10,000 feet continuously over large areas, and around local structures is making detailed structural surveys of faults, deeply buried salt domes and other structures over a much wider area than will ever be covered in detail by drilling. In areas such as the Green River and Powder River basins of Wyoming, it is being used to map the depths of the basins as well as the local structure. In the San Joaquin Valley of California, it has been used to follow the surface of the granite basement westward out to very great depths.

In undrilled sedimentary basins, as for example, that under the llanos in front of the Venezuelan Andes, the seismic method gives a crude picture of the lithologic character of the prism of sediments above the basement as well as giving the approximate depth of the basement.

Probably between 1,000 and 1,500 man-years of geophysical work by technically trained men are being used annually at present by the oil in-

dustry in mapping or in attempting to map, geologic structure. The following statistics give the geophysical activity in the Gulf Coast on February 27, 1937: Seismic crews—88, torsion balance parties—27, magnetometers—3, gravimeters—8, electric crews—2. In effectiveness in advancing geologic information of an area, three to four of those man-years of geophysical work probably are approximately equivalent to one of the man-years of geologic work. (The geophysicist, of course, in general obtains geologic information which the geologist can not obtain, but the geophysical observation of data is expensive both in money and man-hours of work.)

The great contribution of the routine work of oil industry to the geologic knowledge may be characterized briefly as the successful elaboration of the concealed geology and geologic history of many areas.

C. RESEARCH BY INDIVIDUAL OIL GEOLOGISTS NOT IN LINE OF COMPANY WORK

Much creative thought is devoted to fundamental and theoretical geologic problems by oil geologists in odd moments of their time, at the conventions of the Association, at the meetings of the local societies, and often, whenever two or three of them get together. A few oil geologists find time to work up theoretical problems. Most oil geologists are satisfied, however, to satisfy their own intellectual curiosity, and only a very few have the urge to carry their research far enough for publication and to undertake the labor of writing it up and publishing it. The list of theoretical contributions by oil geologists nevertheless is creditably long, as is evidenced by *Problems of Petroleum Geology*, the general and theoretical papers of the *Gulf Coast Oil Fields*, Muir's *Geology of the Tampico Region*, Reed's *Geology of California*, Reed and Hollister's *Structural Evolution of Southern California*, and many papers in the *Bulletin* of the Association. Of the 80 odd papers which are published annually in the *Bulletin*, one quarter to one third involve research or philosophic thought on geologic problems beyond that necessary to the work of the author in line of company duty. In his presidential report, Levorsen calls attention to the fact that an average of only 6 per cent of the membership contributes annually to the Association's publications. One third of those members are in university geologic departments, or are on state surveys or the U. S. Geological Survey. Less than 2 per cent, and probably about 1 per cent, of the oil geologists annually carry research outside the line of routine work through to publication.

D. SYMPOSIA

The large majority of the American oil geologists will work up a paper for publication only under the stimulus of compulsion. A few companies have rather strict rules against publication by their geologists or against the release of data for publication. Published data in regard to a company's producing properties may be used against the company in lawsuits; patent complications affect certain geophysical data; the legal department of many oil companies, therefore, vetoes the release of certain data for publication. But nevertheless the commercial restriction of publication by oil geologists is not nearly as great as it is believed to be by geologists not in oil company work. The plea of commercial restriction of publication commonly is used as an

alibi for disinclination to publish. But under the social pressure of a local group responsible for the program of an annual meeting of the Association, or under the urgent insistence of the chairman of the program committee, or of a man like the late Sidney Powers, or like the editor of *Geology of Natural Gas*, or the editors of the *Gulf Coast Oil Fields*, a great many oil geologists are induced to write up material for publication.

The various symposia and most of the program at each of the annual conventions are expressions of the wealth of material available for publication and of the reluctance of 95 per cent of the oil geologists to publish except under the stimulus of group pressure.

DONALD C. BARTON

March 16, 1937

EXHIBIT VI—B. SUPPLEMENTARY REPORT

At the business meeting of the committee, Tuesday, March 16, 1937, the problem of encouragement of research was discussed at length and action was taken as follows.

1. John L. Rich was requested to take charge of a project, suggested by himself, of taking stock of the fundamental problems of oil geology. Members of the committee are to write him, listing the fundamental, unsolved or only partially solved problems of oil geology. He is to solicit similar opinions from other members of the Association. The list of live fundamental problems is to be published by the committee in the *Bulletin* and used to attempt to interest members of the Association in attacking them.

2. The project of Professors Van Tuyl and Parker in regard to the time of the accumulation of oil and gas was approved. The committee is to support the project to the extent of its ability. Members of the committee and the local societies at the solicitation of members of the committee will be called on shortly by Professors Van Tuyl and Parker to furnish lists of geologists who possibly can and will furnish certain information which they may desire. The committee hopes that all members of the Association will cooperate as far as possible.

3. Following a suggestion by Parker D. Trask, the committee requested him to get in touch with *Science Service* in regard to publicity: (a) in connection with the report of the chairman of the committee in regard to "The State of Geological Research in the Oil"; (b) in regard to the project on live problems of oil geology; and (c) in regard to the value of research in oil geology.

4. According to instructions of the committee, the chairman with the advice of the Society of Economic Mineralogists and Paleontologists is to appoint a subcommittee: (a) to confer with the important committee on micropaleontology of the National Research Council, J. A. Cushman, chairman, in regard to the proper description in publication of the undescribed species and genera; (b) to confer with the American Museum of Natural History in regard to the Brooks Ellis project of compilation of all published data on micro-fossils, more particularly in regard to ways and means of making the compiled data useably available to oil company paleontologists; and (c) if the sub-committee believes it advisable to formulate, a program or alternative programs, for submission to the research committee for possible recommendations to the Association.

5. The committee voted that the key subject of the open meeting of the committee next year should be "The Time of Accumulation of Oil and Gas Deposits."

DONALD C. BARTON

EXHIBIT VII. REPORT OF COMMITTEE ON
APPLICATIONS OF GEOLOGY

This report briefly outlines the activities of the Committee on Applications of Geology for the year 1936-1937. The previous three years' reports of the committee have been published in the May *Bulletins* for each year. This year's work shows continued progress in publicizing geology.

Last year's report of this committee mentioned the detailed report of the Geological Society of America's Committee on publicizing geology, which report suggested coordination of the efforts of the Geological Society of America, the American Association of Petroleum Geologists, and the State Surveys, but little or no progress has been made in unifying these efforts.

The work being done, and that contemplated by the National Park Service is a potent agency in publicizing geology, as indicated by information supplied by Earl A. Trager, chief, Naturalist Division of the National Park Service. The National Parks and Monuments were designated as public playgrounds because of their superlative geologic features and the resulting superb scenery. Many of the 10,000,000 annual visitors to the Parks and monuments are inspired and entertained by the geologic wonders, and their simple explanations.

The present organization of the Park Service places geologists in areas where geology is the major interest, archeologists in the regions pertaining mostly to archeology, historians in historical areas, *et cetera*. There are at present about thirty geologists and assistants in the Washington office, in the Parks, and in the branch of research and education, whose duty it is to inform the traveling public concerning the geology in the Parks and surrounding territory. Also during the summer season, special lectures and talks on geology are given in the Parks at scheduled times. It is obvious that such lectures in Nature's classroom are most impressive.

The Park Service naturalist has made elaborate plans for extending the educational side of geology in the Parks, by the erection of road and trail signs and cross sections pointing out the interesting geological features, by the use of descriptive pamphlets to be used on hiking, horseback and auto trips and by preserving the natural geologic exhibits in the Parks.

The efforts of members of the Association in Oklahoma indicate continued progress in publicizing geology.

The Tulsa Geological Society presented an exhibit at the 1936 International Petroleum Exposition at Tulsa, which included the following items of interest. Pamphlets were distributed indicating applications of geology as pertaining to the petroleum industry; sound moving pictures made by the Park Service in cooperation with the University of Chicago and others, illustrating geological processes were shown and created considerable interest. Several cross sections, illustrating the stratigraphy and structure of the Mid-Continent area were shown. A microscope was available together with slides of well cuttings, showing important formations and producing sands. A sub-surface model of the Oklahoma City field, loaned by the Sinclair-Prairie Oil

Company was also on exhibit. The Tulsa Society had charge of a rather comprehensive display of Oklahoma rocks and minerals. These exhibits created much interest and were well attended by all classes of visitors.

Naturally the high schools and University of Tulsa are interested in presenting geology to their students, but it is surprising the number of people, outside the petroleum industry, who are interested in geology, and attend the University of Tulsa Downtown College, where comprehensive courses in elementary geology are given. Geology is a part of the regular curriculum in the Tulsa high schools.

During the past year, the Oklahoma Geological Survey, Robert H. Dott, Director, conducted a mineral survey of the State, financed by the Works Progress Administration. The work was under the supervision of technical men, mostly geologists, but much of the field work was done by relief clients under the supervision of these technical men.

In the course of this mineral survey, nearly 1,500 people, most of whom had probably never heard of geology, were employed at various times and thus gained some knowledge of the rudiments of geology and its every day application. The newspaper publicity which followed the work in all of the counties, has undoubtedly made the general public more familiar with and interested in the field of geology.

In Texas, the outstanding achievement in publicizing geology was the Humble Oil and Refining Company's geological exhibit at the Centennial in Dallas. This exhibit included the following.

- A. Three paleogeographic maps of Texas and adjacent parts of Mexico, Oklahoma, and New Mexico
 1. Map showing general conditions in Mid-Pennsylvanian time
 2. Map showing general conditions in Woodbine time
 3. Map showing general conditions in Midway time
- B. A relief areal geologic map of Texas and adjacent parts of Mexico, Oklahoma, and New Mexico
- C. A relief structural geologic map of same areas (All the above five maps are presented on a scale of 1 inch to 500,000 feet horizontally, and the relief maps are on a 1 inch to 1,000 feet vertical scale.)
- D. A presentation of four diorama cross sections of the following oil fields
 1. Spindletop
 2. East Texas
 3. Powell
 4. Big Lake (West Texas)(These cross sections were drawn on a horizontal and vertical scale of 1 inch to 250 feet.)

I am indebted to Donald C. Barton for the following comments on the success of this exhibit in popularizing geology. The approximate estimate of attendance at the exhibit last summer was 2,300,000 people. Approximately 300,000 copies of Barton's pamphlet, *250,000,000 Years With Texas*, were distributed to the public. This pamphlet and the companion pamphlet on the historical Dioramas were not given out at the exhibit, but visitors had to sign and mail a card in order to obtain the pamphlets. Approximately 260,000 copies of a pamphlet combining the tale in regard to the historical exhibit with a denatured tale in regard to the geophysical exhibit were distributed to the schools of Texas. These facts are ample proof that much was accomplished in popularizing geology through this exhibit and the pamphlets.

This same exhibit is to be continued this summer intact with, however, the addition of a geophysical exhibit. It is planned to have a seismic truck

and probably a torsion balance and magnetometer. Along with these will be diagrams to explain the workings of the instruments and methods of operation.

The University Lands, under the supervision of Hal P. Bybee of the San Angelo office, furnished a peg model of the Big Lake Oil Field for the Texas Centennial at Dallas.

Ira O. Brown of San Antonio reports that the San Antonio Geological Society's museum continues to grow, both in its material exhibits and its general value to the public. In connection with the museum, this Society maintains a geological library to which has been added recently two complete sets to date of *Annotated Bibliography of Economic Geology*. The San Antonio Society holds occasional meetings which are open to the public on subjects of popular interest. They also conducted a field trip for the benefit of students of St. Mary's University interested in geology.

Olin G. Bell reports results of the Houston group in popularizing geology. Several well advertised meetings were held during the year. The speakers dealt with subjects of interest to the general public on phases of geology other than finding oil. Outstanding among these was a lecture by Chas. N. Gould, on the proposed Big Bend International Park in West Texas and northern Mexico and a series of films from the Department of Commerce prepared by Carey Croneis of the University of Chicago.

Several Houston geologists gave lectures on various phases of geology and geophysics at the University of Houston. Many of the talks at weekly luncheons were of interest to the public, who were invited to attend.

The California group reports a continuation of popularizing geology, and mentions several good permanent exhibits in Los Angeles, including collections of well cores, fossils, structural geology models, drawings, *et cetera*. They also report that the night classes in geology and mineralogy, which were begun four years ago in several of the Los Angeles high schools, are being continued. These classes are taught by assistants or instructors from one or more of the universities located in Southern California. These instructors are selected by the high schools.

The Geological Survey of Missouri continued its many activities which, in the very nature of its work, goes a long way in popularizing geology. McQueen, assistant State geologist, reports a few of the outstanding activities of the Survey during the past year. A great many drillers and citizens of the state were made conscious of the value of geology in the field of underground water supplies. In the survey's work in this connection, upon the completion of a water well, regardless of depth, the survey furnished the drilling contractor with a colored log strip and a complete explanation of it. Likewise, they furnished the owner of each well with a similar log in which an explanation of the formations and other details were given. The Survey also continued to virtually supervise the drilling of all wells for municipal water supplies, which, of course, attracts the attention of the public to the value of geology. The public of Missouri are also conscious of the value and meaning of topographic maps, which is evidenced by the fact that the demand increases for the mapping of areas within the state. The work of the Federal Re-employment Projects was carried on by geologists, engineers, and technically trained men, who were instructed to explain in detail the type of work being done and the results obtained therefrom.

A. E. Brainerd of Denver reports continued progress in the Rocky Mountain district in presenting geology to the public. Geology courses have been introduced into some of the larger high schools of Colorado. The University of Colorado maintains extension courses in various phases of geology in Denver, which in part are taught by members of the Association. Our members in Denver have also talked on geology at luncheons during the past year.

Carey Croneis, committee member at Chicago, reports the results of his work for the past year. Croneis and Krumbein's textbook, entitled *Down to Earth*, has had a gratifying sale to laymen. The Federal Government has ordered 2,000 copies to be distributed to the Civilian Conservation Corps camps in this country. He also reports that during the year he has shown the six reels of geological films prepared in coöperation with the National Park Service and the University of Chicago to many appreciative audiences. He also reports an increasing interest prevailing in the earth sciences, and suggests that the real solution to our problem of popularizing geology will not be solved until we get geology back into the high school curriculum.

FRANK R. CLARK, *chairman*

EXHIBIT VIII. REPORT OF REPRESENTATIVE TO
NATIONAL RESEARCH COUNCIL

I wish to submit for your approval my report to the Association as its representative on the Division of Geology and Geography of the National Research Council. The Division held its annual meeting on May 2, 1936, in Washington, D. C.

After attending this meeting and hearing the reports of the various committees, I was impressed, like Dr. Barton, who represented the Association ex-officio last year (*Bulletin*, Vol. 20, pp. 661-663), with the need of a closer contact and a better understanding between the Division and the Association as to the accomplishments and aims of both. To this end I recommended that your representative each year present to the Division a report of the progress of research by the Association members, whether this research is directly sponsored by the Association or is something, not too confidential, carried on in relation to petroleum geology; and, reciprocally, I recommended that each year your representative present to the Association a report of some of the activities of the Division, more particularly those in which our members may be interested. The former report, made to the Division, should include a statement by the chairman of the research committee of the Association, a statement which will summarize the research work accomplished during the year by our members. I believe that Dr. Barton, now chairman of that committee, concurs with these recommendations and suggestions.

As pointed out by Dr. Barton last year (*Bulletin*, Vol. 20, p. 662), the National Research Council acts "as a national coördinating center for the promotion of research." It endeavors, through many committees, to keep abreast of investigation in the sciences, to prevent unnecessary duplication of effort, and to further worthwhile studies. The Division of Geology and Geography confines its attention to these two sciences.

Within the Division there are several committees, the work of which is of importance to our Association. I shall briefly review these as of last May.

The committee on micropaleontology consists of ten members, of whom

eight are members of the Association, including the chairman, Dr. Joseph A. Cushman.

The report of this committee gives a résumé of work being done in micro-paleontology, and of papers recently printed or soon to be published. It outlines the progress in this subject and especially in the correlation of faunas. Attention was called to the fact that microfossils are being found more abundant in the older formations than had previously been supposed to be the case.

The committee on tectonics has for its main object the compilation of a tectonic map of the United States, on a scale of 1:2,500,000, which is the scale of the geologic map of the United States. The committee has fifteen members, six of whom are members of this Association (Behre, P. B. King, Levorsen, Lovering, R. D. Reed, W. T. Thom).

Each member is assigned a district in which he is collecting all available data on tectonics. These data are compiled on separate sheets, and it was Barton's recommendation that these sheets be displayed, for criticism, before local geological societies and before our Association at its annual convention. I hope that this suggestion is being followed this year.

The committee on tectonics also reports on progress made by the Coast and Geodetic Survey in the study of isostasy.

The committee on stratigraphy, including on its personnel Association members, C. G. Croneis, R. C. Moore, J. B. Reeside, L. W. Stephenson, W. H. Twenhofel, and C. E. Weaver, has devoted its principal efforts to preparation of correlation charts of formations in the United States, Mexico, and the Caribbean region. These charts should be displayed for comments at our convention, as urged by Barton. This committee is contemplating a series of handbooks on the stratigraphy of North America.

On the committee on sedimentation are fourteen members, ten of whom are Association members (Blackwelder, Bramlette, Leighton, Milner, Tarr, Tester, Trowbridge, Twenhofel, Vaughan, and P. D. Trask, chairman). The main object of this committee is the preparation of a symposium on recent sediments. Papers for this symposium should be ready by the fall of 1937. The report of the committee on sedimentation for 1932-1934 was published in late 1935 as *Bulletin 98* of the National Research Council. This committee is also active in preparing a bibliography of papers on sediments, in studying and reporting on the terminology of sediments, and in furthering certain research projects on sedimentation.

The Committee on Conservation of the Scientific Results of Drilling is composed of ten members, seven of whom are Association members (Bay, M. A. Hanna, Lahee, McQueen, Sellards, Thom, and A. C. Tester, chairman).

This committee was reorganized in December, 1935, so that it was not able to accomplish much before the Council meeting on May 2. Its object is the preservation of cuttings and cores from wells, so that these may be studied in the future. It was the consensus of the committee that the best repositories would be State Surveys, but, as may be readily understood, there are difficulties to be overcome in the way of collecting at the well, transporting from the field to the storehouse or laboratory, and cataloguing. The aim of this committee is worthy, and there is probably little objection to furnishing the samples. Since money is in most instances scarce, or not available,

coöperation on the part of the companies drilling the wells will be necessary. However, I believe that the responsibility of soliciting these samples should rest with the state geologist, and that coördination of the efforts by the State Geological Surveys should be volunteered by this committee of the Division. If and when the opportunity comes to our Association members to assist this committee, I trust that coöperation will be willingly given.

In outlining a few of the activities of these committees of the Division, I have in mind informing the Association of what some of our members are doing for the National Research Council, and also acquainting them with the names of persons with whom they can get in touch if they are interested in any of the projects underway.

I am sure that Dr. Edson S. Bastin, chairman of the executive committee of the Division, will gladly advise where information may be secured concerning research work in progress.

FREDERIC H. LAHEE

EXHIBIT IX. REPORT OF RESOLUTIONS COMMITTEE

Be it resolved, that we, members of The American Association of Petroleum Geologists, express our appreciation and thanks to all who have contributed to the success of the twenty-second annual meeting in Los Angeles, California, and particularly to the following.

The Pacific Section, Frank A. Morgan, general chairman of the convention committee, and all other committee chairmen and members.

The wives of the local geologists, and particularly Mrs. W. S. W. Kew, their chairman, for their hospitable entertainment of the visiting ladies.

The Los Angeles Biltmore Hotel and its management for efficient coöperation and service which has made the annual meeting a success.

The many oil companies, supply companies, and geophysical companies, whose generous contributions financed the local expenses; the exhibitors for their excellent technical displays of equipment and scientific services; and others who furnished displays.

The Henry E. Huntington Library and Art Gallery and Bullocks-Wilshire for ladies' entertainment.

The Automobile Club of Southern California for supplying maps and for making possible trips to moving picture studios.

The California Oil and Gas Association and the Midwick Country Club for their important part in the convention entertainment.

The Los Angeles Chamber of Commerce, and the press and trade journals for publicity.

Further, the sincere thanks of this Association is given to L. C. Snider for his efficient and faithful service as editor for the past four years, a task which has taken much valuable time.

Those assembled at this annual meeting feel honored by the presence of three honorary members, Robert T. Hill, W. W. Orcutt, and J. A. Taff.

Be it resolved, that these resolutions be included in the minutes of the meeting and that copies be sent to the individuals and organizations named.

JOHN G. BARTRAM, *chairman*

R. M. BARNES

JOSEPH M. DAWSON

TWENTY-THIRD ANNUAL MEETING, NEW ORLEANS,
LOUISIANA, MARCH, 1938

The twenty-third annual meeting of the Association will be held in New Orleans, Louisiana, in March, 1938, at the invitation of the City of New Orleans, endorsed by the Shreveport Geological Society and the South Louisiana Geological Society. A large attendance is expected. In Louisiana and the surrounding states of Mississippi, Arkansas, Oklahoma, and Texas live the majority of the members and friends of the Association. The fifteenth annual meeting was held in New Orleans in 1930. At that time the total membership of the Association was 2,285; now it is 2,353. At that time the total registered attendance in New Orleans was 980; at Los Angeles, March, 1937, the total attendance was 1,062.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

(See also page 637)

FOR ACTIVE MEMBERSHIP

Thomas Gayleon Andrews, University, Ala.
L. C. Glenn, Clinton R. Stauffer, W. H. Emmons
Robert Freeman George, Wichita, Kan.
Walter W. Larsh, Chas. W. Roop, W. F. Howell
William Whitehill Rand, Beverly Hills, Calif.
E. F. Davis, Roy R. Morse, Thomas L. Bailey

FOR ASSOCIATE MEMBERSHIP

John James Bailey, Shawnee, Okla.
Jack M. Copass, V. G. Hill, H. H. Kister
Clifford Fountain Barber, Beeville, Tex.
Fred P. Shayes, D. G. Barnett, J. M. Hancock
Charles Edward Bradford, Denver, Colo.
Herman F. Davies, Chas. S. Lavington, Chas. E. Erdmann
Philip Diggs Gully, Beeville, Tex.
Fred P. Shayes, J. M. Hancock, D. G. Barnett
Claude M. Harris, Wichita, Kan.
R. E. Shutt, Sherwood Buckstaff, W. C. Bean
Herman Ray Hauptman, Jr., Meade, Kan.
R. E. Shutt, W. C. Bean, Sherwood Buckstaff
Douglas Duke Howard, Shreveport, La.
E. L. Caster, L. A. Barton, S. A. Packard
Clifton Wood Johnson, Alhambra, Calif.
W. S. W. Kew, Rollin Eckis, H. W. Hoots
David Marcel Larrabee, McAlester, Okla.
F. W. DeWolf, Harold R. Wanless, W. C. Bean
Carl L. Larson, Jr., Shawnee, Okla.
Jack M. Copass, V. G. Hill, H. H. Kister
David M. Miller, Beeville, Tex.
Fred P. Shayes, J. M. Hancock, D. G. Barnett
Lloyd M. Pyeatt, Beeville, Tex.
D. G. Barnett, Fred P. Shayes, J. M. Hancock
Fred E. Smith, Houston, Tex.
Alva C. Ellisior, F. W. Rolshausen, L. P. Teas

FOR TRANSFER TO ACTIVE MEMBERSHIP

Jarvis Garst, Sinton, Tex.
Ira H. Stein, R. M. Beatty, J. L. Tatum
J. J. Russell, Jr., Midland, Tex.
O. F. Hedrick, C. E. Yager, Thos. B. Romine
Zenas E. Stucky, Wichita, Kan.
William F. Absher, A. F. Morris, V. E. Monnett

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

CONSTITUTION AND BY-LAWS

(Adopted 1918 and amended 1921, 1922, 1923, 1925, 1927, 1928, 1929, 1930,
1932, 1933, 1935, and 1936)

CONSTITUTION

ARTICLE I. NAME

This Association shall be called "The American Association of Petroleum Geologists," incorporated under the laws of Colorado the 21st day of April, 1924, for a period of twenty (20) years.

ARTICLE II. OBJECT

The object of this Association is to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas and to encourage improvements in the methods of exploring for and exploiting these substances; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and technology of petroleum and natural gas; to maintain a high standard of professional conduct on the part of its members; and to protect the public from the work of inadequately trained and unscrupulous persons posing as petroleum geologists.

ARTICLE III. MEMBERSHIP

Members

SECTION 1. Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions, whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

- Active members alone shall be known as members.

Life Members

SECTION 2. The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.

Associates

SECTION 3. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.

The executive committee may advance to active membership, without the formality of application for such change, those associates who have, subsequent to election, fulfilled the requirements for active membership.

Election to Membership

SECTION 4. Every candidate for admission as a member or associate shall submit a formal application on an application form authorized by the executive committee, signed by him, and endorsed by not less than three members who are in good standing, stating his training and experience and such other facts as the executive committee shall from time to time prescribe. Provided the executive committee, after due consideration, shall judge that the applicant's qualifications meet the requirements of the constitution, they shall cause to be published in the *Bulletin* the applicant's name and the names of his sponsors. If, after at least thirty days have elapsed since such publication, no reason is presented why the applicant should not be admitted, he shall be deemed eligible to membership or to associate membership, as the case may be, and shall be notified of his election.

SECTION 5. An applicant for membership, on being notified of his election in writing, shall pay full membership dues for the current year and on making such payment shall be entitled to receive the entire *Bulletin* for that year. Unless payment of dues is made within thirty (30) days by those living within the continental United States and within ninety (90) days by those living elsewhere, after notice of election has been mailed, the executive committee may rescind the election of the applicant. Upon payment of dues, each applicant for membership shall be furnished with a membership card for the current year, and until such written notice and card are received, he shall in no way be considered a member of the Association.

Honorary Members

SECTION 6. The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the

cause of petroleum geology. Honorary members shall not be required to pay dues.

ARTICLE IV. OFFICERS AND THEIR DUTIES

Officers

SECTION 1. The officers of the Association shall be a president, a vice-president, a secretary-treasurer, and an editor. These, together with the past president, shall constitute the executive committee and managers of the Association.

SECTION 2. The officers shall be elected annually from the Association at large by written ballot deposited in a locked ballot box by those members, present at the annual meeting, who have paid their current dues and are otherwise qualified under the constitution. Each candidate, when voted for as a candidate for the particular office for which he is nominated, shall be thereby automatically voted for as a candidate for the executive committee for one year, except that candidates for the presidency shall be automatically voted for as candidate for the executive committee for two years.

SECTION 3. No one shall hold the office of president for two consecutive years and no one shall hold any other office for more than two consecutive years except the editor who shall not hold office for more than six consecutive years.

Duties of Officers

SECTION 4. The president shall be the presiding officer at all meetings of the Association, shall take cognizance of the acts of the Association and of its officers, shall appoint such committees as are required for the purposes of the Association, and shall delegate members to represent the Association. He may, at his option, serve on, and may be chairman of, any committee.

SECTION 5. The vice-president shall assume the office of president in case of a vacancy from any cause in that office and shall assume the duties of president in case of the absence or disability of the latter.

SECTION 6. The secretary-treasurer shall assume the duties of president in case of the absence of both the president and vice-president. He shall have charge of the financial affairs of the Association and shall annually submit reports as secretary-treasurer covering the fiscal year. He shall receive all funds of the Association, and, under the direction of the executive committee, shall disburse all funds of the Association. He shall cause an audit to be prepared annually by a public accountant at the expense of the Association. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Association funds. The amount of such bonds shall be set by the executive committee and the expense shall be borne by the Association. The funds of the Association shall be disbursed by check as authorized by the executive committee.

SECTION 7. The editor shall be in charge of editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the *Bulletin* and for special publications, and, with the approval of the executive committee, may accept or reject material offered for publication. He may appoint associate, regional, and special editors.

SECTION 8. The officers shall assume the duties of their respective offices immediately after the annual meeting in which they are elected.

ARTICLE V. EXECUTIVE COMMITTEE—MEETINGS AND DUTIES

Executive Committee

SECTION 1. The executive committee shall consist of the president, past president, vice-president, secretary-treasurer, and editor.

Meetings and Duties

SECTION 2. The executive committee shall meet immediately preceding the annual meeting and at the call of the president may hold meetings when and where thought advisable, to conduct the affairs of the Association. A joint meeting of the outgoing and incoming executive committees shall be held immediately after the close of the annual Association business meeting. Members of the executive committee may vote by proxy on matters which require a unanimous vote.

SECTION 3. The Executive committee shall consider all nominations for membership and pass on the qualifications of the applicants; shall have control and management of the affairs and funds of the Association; shall determine the manner of publication and pass on the material presented for publication; and shall designate the place of the annual meeting. They are empowered to establish a business headquarters for the Association, and to employ such persons as are needed to conduct the business of the Association. They are empowered to accept, create, and maintain special funds for publication, research, and other purposes. They are empowered to make investments of both general and special funds of the Association. Trust funds may be created giving to the trustees, appointed for such purpose such direction as to investments as seems desirable to the executive committee to accomplish any of its objects and purposes, but no such trust funds shall be created unless they are revocable upon ninety (90) days' notice.

ARTICLE VI. MEETINGS

The Association shall hold at least one stated meeting each year, which shall be the annual meeting. This meeting shall be held in March at a time and place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting shall be read, Association business shall be transacted, scientific papers shall be read and discussed, and officers for the ensuing year shall be elected.

ARTICLE VII. AMENDMENTS

Amendments to this constitution may be proposed by a resolution of the executive committee, by a constitutional committee appointed by the president, or in writing by any ten members of the Association. All such resolutions or proposals must be submitted at the annual meeting of the business committee of the Association as provided in the by-laws, and only the business committee shall make recommendations concerning proposed constitutional changes at the annual Association business meeting. If such recommendations by the business committee shall be favorably acted on at the annual Association business meeting, the secretary-treasurer shall arrange for a ballot of the membership by mail within thirty (30) days after said annual Association business meeting, and a majority vote of the ballots received within ninety (90) days of their mailing shall be sufficient to amend. The legality of all

amendments must be determined by the executive committee prior to balloting.

BY-LAWS

ARTICLE I. DUES

SECTION 1. The fiscal year of the Association shall correspond with the calendar year.

SECTION 2. The annual dues of members of the Association shall be ten dollars (\$10.00). The annual dues of associates for not to exceed three years after election shall be six dollars (\$6.00); for the second three-year period eight dollars (\$8.00); thereafter, the annual dues of such associates shall be ten dollars (\$10.00). The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member and associate before January first of each year, stating the amount of the annual dues and the penalty and conditions for default in payment. Members or associates who shall fail to pay their annual dues by April first shall not receive copies of the April *Bulletin* or succeeding *Bulletins*, nor shall they be privileged to buy Association special publications at prices made to the membership, until such arrears are met.

SECTION 3. On the payment of two hundred dollars (\$200.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues. The funds derived from this source shall be placed in a permanent investment, the income from which shall be devoted to the same purposes as the regular dues.

ARTICLE II. RESIGNATION—SUSPENSION—EXPULSION

SECTION 1. Any member or associate may resign from the Association at any time. Such resignation shall be in writing and shall be accepted by the executive committee, subject to the payment of all outstanding dues and obligations of the resigning member or associate.

SECTION 2. Any member or associate who is more than a year delinquent (in arrears) in payment of dues shall be suspended from the Association. Any delinquent or suspended member or associate, at his own option, may request in writing that he be dropped from the Association and such request shall be granted by the executive committee. Any member or associate more than two years in arrears shall be dropped from the Association. The time of payment of delinquent dues for either one year or two years may be extended by unanimous vote of the executive committee.

SECTION 3. Any member or associate who resigns or is dropped under the provisions of Sections 1 and 2 of this article ceases to have any rights in the Association and ceases to incur further indebtedness to the Association.

SECTION 4. Any person who has ceased to be a member or associate under Section 1 or Section 2 of this article may be reinstated by unanimous vote of the executive committee subject to the payment of any outstanding dues and obligations which were incurred, prior to the date when he ceased to be a member or associate of the Association.

In the case of any member or associate who has been dropped between the dates of January 1, 1931, and January 1, 1936, for non-payment of dues and who shall apply for reinstatement, the executive committee is authorized, at its discretion, to accept the resignation of such member or associate effective at any date during such period of delinquency, provided, the member shall pay all indebtedness to the Association incurred prior to the date of

such resignation including a proper proportion of annual dues as shall be fixed by the executive committee. Such member or associate shall not be entitled to receive the *Bulletin* for any period subsequent to the date when his resignation became effective and prior to his reinstatement.

SECTION 5. Any member or associate who, after being granted a hearing by the executive committee, shall be found guilty of a violation of the code of ethics of this Association or shall be found guilty of a violation of the established principles of professional ethics, or shall be found guilty of having made a false or misleading statement in his application for membership in the Association, may be suspended or expelled from the Association by unanimous vote of the executive committee. The decision of the executive committee in all matters pertaining to the interpretation and execution of the provisions of this section shall be final.

ARTICLE III. PUBLICATIONS

SECTION 1. The proceedings of the annual meeting and the papers presented at such meeting shall be published at the discretion of the executive committee in the Association *Bulletin* or in such other form as the executive committee may decide best meets the needs of the membership of the Association.

SECTION 2. The payment of annual dues for any fiscal year entitles the member or associate to receive without further charge a copy of the *Bulletin* of the Association for that year.

SECTION 3. The executive committee may authorize the printing of special publications to be financed by the Association from its general, publication, or special funds and offered for sale to members and associates in good standing at not less than cost of publication and distribution.

ARTICLE IV. REGIONAL SECTIONS, TECHNICAL DIVISIONS, AND AFFILIATED SOCIETIES

SECTION 1. Regional sections of the Association may be established provided the members of such sections are members of the Association and shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular annual meeting, an affirmative vote of two-thirds of the members present and voting being necessary for the establishment of such a section; and provided that the Association may revoke the charter of any regional section by a vote of two-thirds of the members present and voting at a regular annual meeting.

SECTION 2. Technical divisions may be established, provided the members interested shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular meeting, an affirmative vote of two-thirds of the membership present and voting being necessary for the establishment of such a division. In like manner, the Association may dissolve a division by an affirmative vote of two-thirds of the members present and voting at any annual meeting. A technical division may have its own officers, and it may have its own constitution and by-laws provided that, in the opinion of the executive committee, these do not conflict with the constitution and by-laws of the Association. The executive committee shall be empowered to make arrangements with the officers of the division for the conduct of the business of the division. A divi-

sion may admit to affiliate membership in the division specially qualified persons who are not eligible to membership in the Association. Technical divisions may affiliate with other scientific societies, with the approval of the executive committee.

SECTION 3. Subject to the affirmative vote of two-thirds of the membership present and voting at an annual meeting, and with legal advice, the executive committee may arrange for the affiliation with the Association of duly organized groups or societies, which by object, aims, constitution, by-laws, or practice are developing the study of geology or petroleum technology. In like manner and with like advice, the executive committee may arrange conditions for dissolution of such affiliations. Affiliation with the Association need not prevent affiliation with other scientific societies. Members of affiliated societies who are not members of the Association, shall not have the privilege of advertising their affiliation with the Association on professional cards or otherwise.

ARTICLE V. DISTRICT REPRESENTATIVES

The executive committee shall cause to be elected district representatives from districts which it shall define by a local geographic grouping of the membership. Such districts shall be redesignated and redefined by the executive committee as often as seems advisable. Each district shall be entitled to one representative for each seventy-five members, but this shall not deprive any designated district of at least one representative. The representatives so apportioned shall be chosen from the membership of the district by a written ballot arranged by the executive committee. They shall hold office for two years, their term of office expiring at the close of the annual meeting.

ARTICLE VI. BUSINESS COMMITTEE

There shall be a business committee to act as a council and advisory board to the executive committee and the Association. This committee shall consist of the executive committee, not more than five members at large appointed by the president, two members elected by and from each technical division, and the district representatives. The president shall also appoint a chairman and a vice-chairman, but neither of these need be one of those otherwise constituting the business committee. The secretary-treasurer shall act as secretary of the business committee. If a district or technical representative is unable to be present at any meeting of the committee he may designate an alternate, who, in the case of a district representative, may or may not be a resident of the district he is asked to represent, and the alternate, on presentation of such a designation in writing, shall have the same powers and privileges as a regularly chosen representative. The business committee shall meet the day before the annual meeting at which all proposed changes in the constitution or by-laws shall be considered, all old and new business shall be discussed, and recommendations shall be voted for presentation at the annual meeting.

ARTICLE VII. AMENDMENTS

These by-laws may be amended by vote of three-fourths of the members present and voting at any annual meeting, provided that such changes shall have been recommended to the meeting by the business committee and provided that their legality shall be determined by the executive committee prior to publication.

SEVENTEENTH INTERNATIONAL GEOLOGICAL CONGRESS
MOSCOW, JULY 20-29, 1937

President Fuqua has appointed the following members as official Association delegates to the seventeenth International Geological Congress at Moscow, July 20-29; Oliver B. Hopkins, Henry V. Howe, Lewis B. Kellum, Leroy T. Patton, J. P. Schumacher, J. Elmer Thomas, and W. E. Wrather.

SECOND WORLD PETROLEUM CONGRESS
PARIS, JUNE 14-19, 1937

The following papers have been prepared under the direction of the A.A.P.G. program committee, Winthrop P. Haynes, chairman, assisted by Donald C. Barton and James Terry Duce, for the geology and geophysics division of the second World Petroleum Congress at Paris, France, June 14-19.

ANON., "Progress in Petroleum Production in the United States for the Years 1935 and 1936"

ANON., "Progress in Petroleum Production in Venezuela for the Years 1935 and 1936"

E. E. ROSAIRE, "Resumé on Geophysics"

J. E. BRANTLY, "Improvements in Rotary Drilling Equipment Since 1933"

J. J. DONNELLY, "Modern Pumping Practices"

President Fuqua has appointed the following members as official Association delegates to the Congress: J. P. Schumacher and Stanley B. White.

FIRST VENEZUELAN GEOLOGICAL CONGRESS
CARACAS, FEBRUARY 15-18, 1937

The following program was presented by the first Venezuelan Geological Congress, which was held at Caracas, Venezuela, February 15-18, 1937.

"Notas Geológicas Relativas a la Parte Central de la Cordillera de la Costa," by Santiago E. Aguerrevere and Guillermo Zuloaga

"Some Observations on Cretaceous and Pre-Cretaceous Beds in Western and Central Venezuela," by L. Kehr

"Stratigraphy of the Mene Grande Area," by G. E. Tash

"Eocene of the Bolivar Coast Fields," by Ralph G. Hubman

"Paleontology of Bolivar Coast Fields," by M. W. Haas

"Stratigraphy of West Buchivacoa," by G. W. Halse

"Synopsis of Formations of Western Part of Maracaibo Lake Basin," by Hollis

D. Hedberg and L. C. Sass

"Stratigraphy of Rio Querecual Section of Northeastern Anzoátegui," by Hollis D. Hedberg

"New Genus of Foraminifera from the Miocene of Venezuela and Trinidad," by William S. Hoffmeister and Charles F. Berry

"Comparison of Maracaibo and Maturin Sedimentary Basins," by C. Wiedenmayer

"Geología General y Estratigrafía de la Región de Cumarebo, Estado Falcón," by Clemente González de Juana

"Las Rocas Cuaternarias en la Región del Dique de Macarao," by D. W. Grenouillet

"Contribución a la Geología del Sur-Oeste de los Andes de Venezuela," by Victor Oppenheim

"Notas sobre la Formación Punta Gavilán en la Región Oriental del Estado Falcón," by H. N. Suter

"Geological Section in the Barinas Area," by A. N. Mackenzie

"Los Grandes Mamíferos Fósiles de la Región de Barquisimeto," by H. Nectario Maria

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Memorial

JOHN FRANKLIN KINKEL
(1899-1936)



John Franklin Kinkel, an active and successful petroleum geologist of Wichita, Kansas, died September 28, 1936. His death was due to pneumonia with which he was taken ill six days earlier. He made a valiant struggle

against the progress of this disease, and for a time his strength seemed to have prevailed against it.

John was born in Hutchinson, Kansas, on July 10, 1899. He attended the University of Kansas from 1917 to 1921 where he received his degree in geology. He was an active member of the Association since 1925, and a member of Sigma Chi, Tau Beta Pi, and Sigma Gamma Epsilon fraternities.

He worked in the Basin district of Venezuela in 1921 for the New England Oil Corporation and the Sun Oil Company.

During the years 1922 to 1924 he was engaged in field work in western Kansas for Keys Petroleum Company. This early work in what was then an undeveloped and little explored area engendered in him a confidence and enthusiasm for its future which never wavered. The later developments in this area have given fullest endorsement to his judgment.

In 1925 he became associated with The California Company and for more than a year thereafter worked in the Rocky Mountain area.

In 1926 he returned to Kansas where he was employed by the Sinclair Oil and Gas Company.

In 1928 he was employed by the Independent Oil and Gas Company as their resident geologist at Wichita, Kansas. The following year he was transferred to California.

Returning to Kansas in 1930, he practiced his profession as a consulting geologist until 1933 when he entered the services of the Phillips Petroleum Company in Oklahoma. He again returned to Kansas in 1934 as resident geologist at Wichita, which position he held at the time of his death. To his later work in Kansas he brought the wealth of his experience in that state and other areas, and he ably performed the responsibilities of his position.

Members of his immediate family are his wife, Margaret Hardman Kinkel, and a son, Jack, age nine. His brother William C. Kinkel is a geologist for the Ohio Oil Company at San Angelo, Texas. He is also survived by his parents Mr. and Mrs. John M. Kinkel, and a brother Paul, who reside at Topeka, Kansas.

His life was all too short, yet it was neither incomplete in its entity nor deficient in its attainment. He stood well toward the top in his profession, and his associates and friends learned to rely on his professional judgment and his utmost conscientiousness. He has given us a stirring example by his warm-hearted and loyal devotion in all his contacts and many of us will cherish the memory of a strong and true friend.

F. G. HOLL

WICHITA, KANSAS
April 1, 1937

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

The Ardmore Geological Society, Ardmore, Oklahoma, has elected the following officers: president, LINN M. FARISH, Sinclair Prairie Oil Company; vice-president, ED I. THOMPSON, Phillips Petroleum Company; secretary-treasurer, DON O. CHAPPELL, Shell Petroleum Corporation. The meetings are to be held the first Tuesday of each month from October to May, inclusive, at 7:30 P.M., Dornick Hills Country Club.

ARNOLD C. DAHL, of the Shell Petroleum Corporation, has been transferred from Greenwich, Kansas, to Pampa, Texas.

OLIN G. BELL, of the geological staff of the Humble Oil and Refining Company, has been transferred from Laredo to Houston, Texas.

DILWORTH S. HAGER has changed his office address from the Tower Petroleum Building to the Liberty Bank Building, Dallas, Texas.

KATHARINE W. CARMAN, geologist for the Felmont Corporation, has transferred her headquarters from the Houston offices of the company to the Dallas office.

FRANK C. GREENE, of the Missouri Geological Survey, has been transferred from Rolla, Missouri, to the Survey's new office in Kansas City for the northwestern area of the state. His address will be Biltmore Arms, 900 East 9th Street.

J. D. TOMPKINS, president of the Acme Oil and Royalty Company, recently moved his office to Midland, Texas. His mailing address is Box 1332.

S. J. SHAND, of the University of Stellenbosch, South Africa, has been appointed professor of geology at Columbia University and will conduct the courses in petrology. Professor Shand will arrive at the University in September.

R. H. LYNN, formerly vice-president of the Phillips Petroleum Company, and DEAN MCGEE, formerly chief geologist for the same company, resigned to join the A. & K. Petroleum Company, Oklahoma City, Oklahoma.

JAMES D. WHEELER, resident engineer for The Ohio Oil Company in the Yates field, will replace LYNDON L. FOLEY as petroleum engineer in the Tulsa office of the company.

A. ALLEN WEYMOUTH has changed his address from Bahrein Island, Persian Gulf, to 2432 First Avenue North, Seattle, Washington.

D. DALE CONDIT, who is on a business trip visiting several countries, may be addressed in care of H. St. John Harvey, 83 Lexington Avenue, Bloomfield, New Jersey.

BYRON RIFE, independent operator of San Antonio, has become associated with HENRY A. LEY of Fort Worth and will engage in the exploration

of oil and gas prospects in south Texas. Permanent offices are in the Milam Building, San Antonio.

E. V. WHITWELL, formerly manager of the exploration department of the Standard Oil Company of Louisiana, is now head of the geological division of the Carter Oil Company, replacing D. C. NUFER, who resigned to enter private business. Whitwell's address is Box 801, Tulsa, Oklahoma.

FREDERICK G. CLAPP has been in Asia during the past year. He went to Afghanistan, via India, in May, 1936, and spent the summer in Kabul and northern Afghanistan, where some explorations were made beyond the Hindu Kush; motored to Teheran late in August, via the deserts of southern Afghanistan; continued to Baghdad and by rail to Berlin. He returned in December to Teheran, where he remained until after the end of the year. He is expected back at his office, 50 Church Street, New York City, in May, 1937.

The Geological Survey of Newfoundland has been revived. A. K. SNEL-GROVE, assistant professor of geology at Princeton University is Government geologist and C. K. HOWSE is assistant Government geologist.

DON L. HYATT, of the Carter Oil Company, has been transferred from the position of district geologist at Ada to that of division geologist at Wilson, Oklahoma.

O. A. SEAGER, geologist of the Carter Oil Company, has moved from Wilson, Oklahoma, to Lewiston, Montana.

HUNTLEY AND HUNTLEY, 2711 Grant Building, Pittsburgh, Pennsylvania, announce the installation of a seismic reflection service under the direction of H. RUTHERFORD, seismologist in charge, University of Pittsburgh.

R. C. MOORE spoke before the Tulsa Geological Society, April 5, on "The Carboniferous System."

The officers of the Alberta Society of Petroleum Geologists are: J. D. SPRATT, president; J. S. IRWIN, vice-president; S. E. SLIPPER, secretary-treasurer; and H. M. HUNTER, business representative for the year 1937.

C. EDGAR HANNUM is working in the geological department of The Texas Company with headquarters at Ardmore, Oklahoma.

SAMUEL H. GLASSMIRE, attorney of Tulsa, Oklahoma, spoke before the North Texas Geological Society at Wichita Falls, Texas, April 6, on "Law of Oil and Gas Leases and Royalties."

H. HAROLD TRAGER is in the geological department of the Atlantic Refining Company, at Hutchinson, Kansas.

E. E. ROSAIRE severed his connection with the Independent Exploration Company, March 27, 1937, and has moved his office to 321 Esperson Building, Houston, Texas. He will engage in experimental geophysics and geochemistry.

HUGH TANNER is employed by The Ohio Oil Company at San Angelo, Texas.

A. E. BRAINERD and C. S. LAVINGTON spoke before the Rocky Mountain Association of Petroleum Geologists, at Denver, Colorado, April 5, on "Petroleum Developments in the Rocky Mountain Region during 1936."

RUSSELL S. KNAPPEN, assistant to the vice-president of the Gulf Oil Corporation, Tulsa, spoke at a dinner at the Hotel Astor, New York, honoring CHARLES P. BERKEY, head of the engineering department at Columbia University, on his seventieth birthday.

OSCAR HATCHER has resigned as chairman of the Ada chapter of the American Petroleum Institute and is succeeded by IRA KING. Hatcher will continue as executive vice-chairman. He has joined Petroleum Geologists, Incorporated.

A. B. BRYAN, former professor of physics at Rice Institute, Houston, Texas, was placed in charge of the geophysical division of the Carter Oil Company, replacing STUART SHERAR, resigned. G. E. WAGONER will be his assistant.

KARL H. SCHMIDT is director of surveys of the Magnetic Prospecting Company of Houston, Texas. He is still carrying on his work with the American Askania Corporation.

J. M. WANENMACHER, formerly in charge of subsurface work in the production department of the Shell Petroleum Corporation in Tulsa, has been transferred to McPherson, Kansas, where he will supervise exploitation engineering work in that state. His new address is 923 South Maple Street, McPherson.

MERLE C. ISRAELSKY, chief paleontologist of the United Gas System, Houston, Texas, addressed the Shreveport Geological Society, April 2, on "General Correlation."

DAN C. NUFER, formerly head of the geological division of the Carter Oil Company, Tulsa, and GLENN SCOTT DILLE, have formed a partnership to do consulting geological work and will maintain offices at 509 Atlas Life Building, Tulsa.

R. W. SHERMAN of the Barnsdall Oil Company, California, has resigned. After a brief vacation he will maintain offices in Los Angeles for consulting work.

W. C. ILLING, professor of geology of the Royal School of Mines, London, England, and consulting geologist for the Anglo Persian Oil Company, spent the latter part of March in the United States. On March 31, he spoke before the Dallas Petroleum Geologists on oil-finding in Trinidad, Venezuela, Europe, and England, and high tribute was paid to Americans for advancement in geophysical prospecting and production methods. Strict adherence to the anticlinal theory of accumulation was condemned in the light of important discoveries of oil in synclines, and in beds overlying fresh-water strata in Trinidad and Venezuela. It was pointed out that the potentialities of hydrogenation can not be underestimated and the petroleum industry should prepare to "move over" to make room for this successful process of manufactur-

ing petrol. Low efficiencies of recovery in the petroleum industry were contrasted with the high efficiencies attained in mining of other minerals.

HENRY V. HOWE, head of the School of Geology at Louisiana State University, Baton Rouge, recently elected secretary-treasurer of the Society of Economic Paleontologists and Mineralogists, will be in Europe until October. He is one of the Association's delegates to the International Geological Congress at Moscow this summer. During his absence, communications for secretary-treasurer's office should be sent to Gayle Scott, Texas Christian University, Fort Worth, Texas.

E. W. ELLSWORTH, formerly of Tulsa, is now at Laurenceville, Illinois.

H. F. MOSES, of the Carter Oil Company, has moved from Saginaw, Michigan, to Mattoon, Illinois.

EUGENE E. BROSSARD, formerly with the Venezuela Gulf Oil Company, Ciudad Bolivar, Venezuela, is now associated with the Mene Grande Oil Company of that city.

MAX W. BALL, who is associated with the Abasand Oils, Ltd., is making his headquarters at Edmonton, Alberta, to which city the executive offices of the company have been moved from Toronto.

FRANK A. MORGAN, formerly vice-president and manager of the production, land, and geological departments of Rio Grande Oil Company with headquarters in Los Angeles has been appointed director of exploration and lands of the new Richfield Oil Corporation. The new company was created, effective March 12, by the merging of Rio Grande Oil Company with the original Richfield Oil Company of California and Pan American Petroleum Company. The new address is Richfield Building, 555 South Flower Street, Los Angeles.

JOHN G. BARTRAM of Casper, Wyoming, was the speaker at the meeting of the Rocky Mountain Association of Petroleum Geologists, held in Denver, April 19. His subject was "The Upper Cretaceous of the Rocky Mountain Area."

WILLIAM TAYLOR THOM, JR., has been designated Blair Professor of Geology, succeeding the late Professor ALEXANDER HAMILTON PHILLIPS, at Princeton University. Thom is the Association representative in the Appalachian district.

The West Texas Geological Society sponsored a field trip to the Hueco and Franklin mountains of West Texas April 24 and 25.

The annual meeting of the Eastern District of the American Petroleum Institute, Division of Production, was held in Columbus, Ohio, May 6 and 7. Among the papers presented were the following: "Future Possibilities of Michigan Oil and Gas Production," by VIRGIL R. D. KIRKHAM; "Recovery and Repressuring in Deep and Shallow Sands in the Eastern Area," by WILBUR STOUT; "Prospect of Deep Production in the Illinois Basin," by THERON WASSON; and "Use of Geophysical Methods in Oriskany Production," by L. E. RANDALL.


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<p align="center">OKLAHOMA CITY GEOLOGICAL SOCIETY OKLAHOMA CITY, OKLAHOMA</p> <p><i>President</i> - Leland W. Jones Ohio Oil Company, Edmond <i>Vice-President</i> - E. A. Paschal Coline Oil Company <i>Secretary-Treasurer</i> - H. L. Crockett Colcord Building Meetings: Second Monday, each month, 8:00 P.M., Commerce Exchange Building. Luncheons: Every Monday, 12:15 P.M., Commerce Exchange Building.</p>	<p align="center">SHAWNEE GEOLOGICAL SOCIETY SHAWNEE, OKLAHOMA</p> <p><i>President</i> - Jack M. Copass Amerada Petroleum Corporation <i>Vice-President</i> - Don L. Hyatt Carter Oil Company <i>Secretary-Treasurer</i> - M. C. Roberts The Texas Company Meets the fourth Monday of each month at 8:00 P.M., at the Aldridge Hotel. Visiting geologists welcome.</p>
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Luncheons: Fourth Friday, each month, at 12:15 P.M.

Place: Hamilton Building

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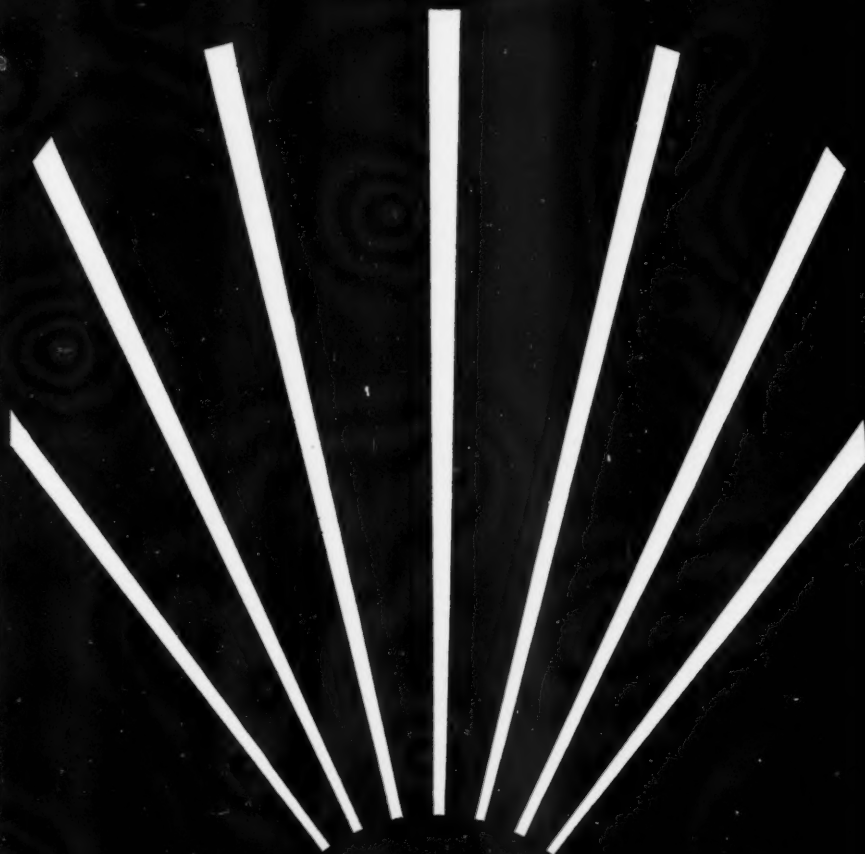
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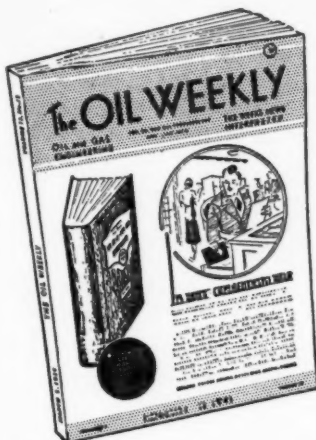
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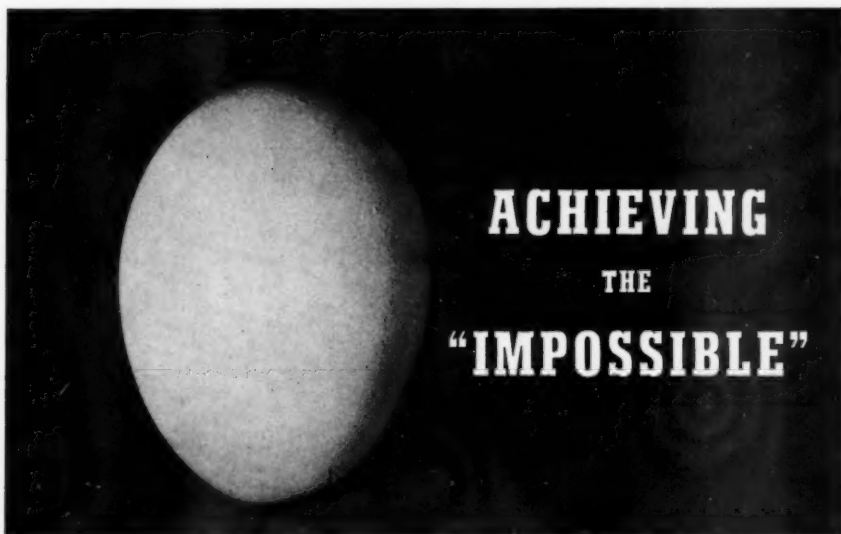
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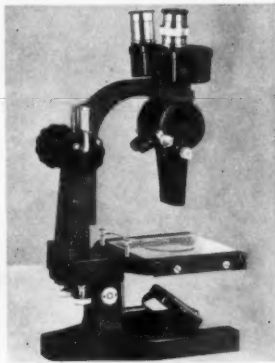
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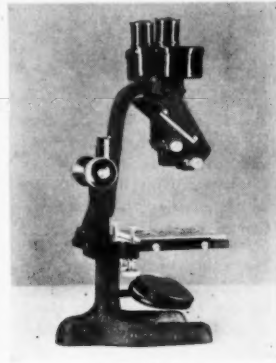
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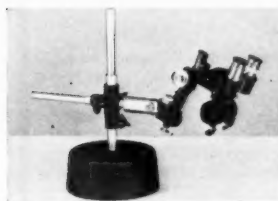
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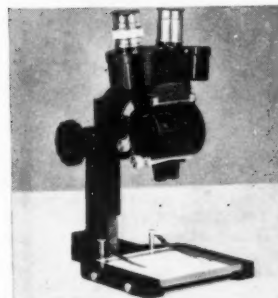
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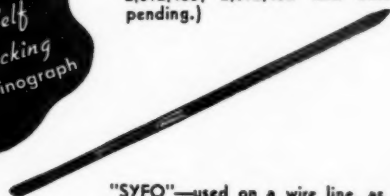
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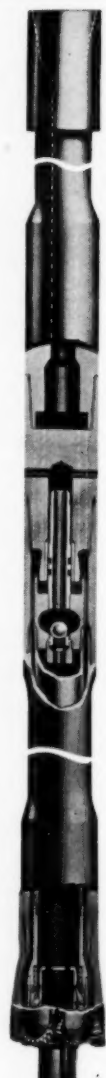
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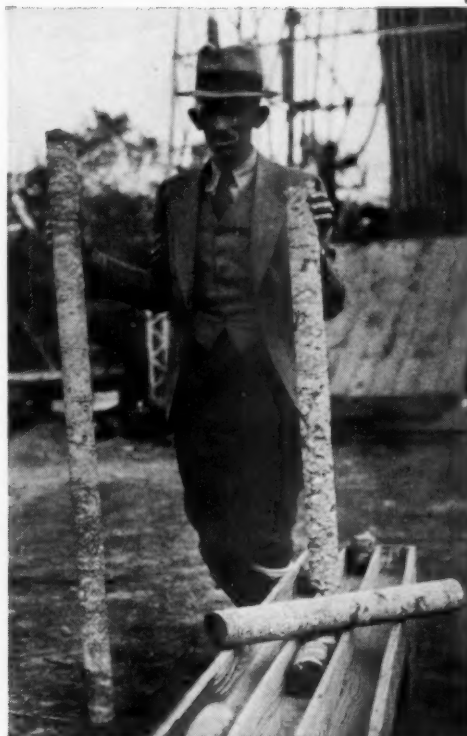
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